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OF

SCIENCE AND ARTS.

CONDUCTED BY

PROFESSORS B. SILLIMAN, B. SILLIMAN, JR.,

AND

JAMES D. DANA,

IN CONNECTION WITH

PROF. ASA GRAY, OF CAMBRIDGE,
PROF. LOUIS AGASSIZ, OF CAMBRIDGE,
DR. WOLCOTT GIBBS, OF NEW YORK.

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[SECOND SERIES.]

ART. XII.—*On the Measurement of the Pressure of Fired Gunpowder in its Practical Applications;* by WILLIAM E. WOODBRIDGE, M.D.

EARLY in the history of scientific gunnery the pressure of the gases generated by the combustion of gunpowder was made the subject of inquiry and experiment. Gen. Antoni of the Sardinian army, writing about the year 1785, narrated experiments on this subject, and stated that fine war-powder fired in a cylindric cavity half an inch in diameter and height, with no other opening for escape than the vent through which it was fired, exerted a pressure of from 1900 to 1400 atmospheres. This he deduced from the weight required to close the orifice of the eprouvette against the force of the explosion.

Count Rumford, in his experiments made in 1793, on the same subject, used an apparatus in which the escape of gas by the vent was prevented; the powder being fired by heating the closed end of a tube filled with it and communicating with the interior of his eprouvette. The pressure of the gases was measured by the means before referred to. The capacity of his eprouvette was about 25·5 grains of powder. With this apparatus he experimented on the force exerted by different charges from one grain upward, and from the results constructed an empirical formula, expressing very nearly the relation of the indicated expansive force of the gases to their density. The maximum

force of fired gunpowder he deduced from that estimated sufficient for the rupture of his eprouvette, which was burst by a charge filling its cavity, and concluded it to be not less than 54750 atmospheres. Although his conclusions have not always been received as rigorously correct, and some must be considered to be very erroneous, the experiments have ever since been regarded as furnishing important data, and have been made the subject of careful analysis, especially by Piobert, with reference to the circumstances of practice.

The principles on which to estimate the strength of hollow cylinders were not well understood at the time of Count Rumford's experiments; and the strength of his eprouvette was not more than one-tenth of that which he assigned to it. It does not, however, necessarily follow that the estimated bursting pressure must be reduced in the same ratio, since the relations of successive rupture to time are but imperfectly known.

The following experiment seems to show that the extreme force of gunpowder fired in small quantities does not exceed 6200 atmospheres. I enclosed in a hollow cylinder of cast-steel $1\frac{1}{8}$ inch in exterior diameter and $\frac{1}{4}$ inch in diameter interiorly, 20 grains of Hazzard's Kentucky rifle powder, which filled, loosely, the cavity. This was fired by a flash of powder penetrating through the aperture of a valve (of steel) opening inward, but designed to prevent the escape of gas outward. The cylinder was not ruptured, and being put under water, no gas was found to escape. (The weight of the instrument was too great to test the loss of gas by my scales.) On pressing in the valve by means of a screw, an abundance of gas escaped, carrying with it the odor of sulphuretted hydrogen. The seat of the valve was found to remain perfect, a fact which when compared with a former trial in which the gases escaped in consequence of a slight defect of the valve, is presumptive proof of its immediate action. The residuum was found to weigh 10·45 grains. The calculated strength of the cylinder would be equal to an internal pressure of about 93000 lbs. per square inch, or 6200 atmospheres of 15 lbs.

In the experiments above mentioned, the quantities of powder employed were small and the circumstances under which it was exploded were very different from those attending the firing of it in practice. Desirous of ascertaining the actual pressures sustained by fire-arms of different calibres, when fired with charges variously modified, by a method more exact than the deductions from these experiments afforded, I was led to devise the plan which will now be presented, together with some account of such experiments as have already been made in accordance with it.

I proposed to ascertain the pressure of the gases evolved by the combustion of gunpowder, by including in the cavity within

which the pressure was restrained, a *piezometer** which by registering the compression of the oil which it contained, should indicate the pressure .to which it was exposed. The piezometer used in the experiments is a small cylindrical vessel of steel, inclosing a quantity of oil which receives the pressure of the fluid by which it may be surrounded through the medium of a piston which will move inward a distance proportioned to the amount of compression. To the piston is attached a stem of wire, projecting inward, and receiving on its side the pressure of a fine point, which, when the piston is moved, makes a line on the stem, equal in length to the distance through which the piston moves. In order that the mark may be more distinctly visible, the stem is coated with a thin film of black varnish. A partial rotation of the piston, after the adjustment of the quantity of oil, inscribes a transverse line on the stem, from which to measure the one denoting the compression. The length of the mark is measured under the microscope by means of a rule divided into $\frac{1}{1000}$ths of an inch. The details of the construction of the piezometer are arranged with reference to obtaining as great capacity and as great length of stroke as its exterior dimensions would permit—to fixing the proper relation between the area of the piston, the capacity of the instrument and the pressures to which it was to be subjected, and to its being easily filled with oil, and the quantity adjusted without including air.

The experiments on the compressibility of oil necessary to determine the pressure per square inch corresponding with a given length of stroke, at a given temperature, were carefully made. The amount of compression was subject to actual inspection, up to pressures of 10,000 lbs. per square inch. The oil submitted to trial was enclosed in an instrument of glass consisting of a bulb and graduated tube. The scale upon the tube was marked by means of a dividing-machine, and the capacities of its divisions were equal, so far as determined by a careful examination with columns of mercury, of different lengths. The capacity of each division was equal to one part in 3762·2 of the volume of the oil at 60° Fahr. To the bore of the tube (0·038 in., in diameter) was fitted an iron piston, packed by a ring of mercury occupying a groove turned in its edge. This arrangement was found to favor accurate observation, and to answer its purpose well in all respects. The instrument was enclosed in a strong tubular receiver, having windows of glass, through which it could be inspected. The windows are truncated cones, having their bases inward, and are fitted to conical cavities in opposite sides of the receiver. A rack and pinion, worked by a little shaft passing through the side of the receiver, serve to bring all

* The use of the word *piezometer* to denote an instrument for the measurement of pressure instead of compression, certainly accords with its derivation.

parts of the graduated tube successively in view. The receiver was connected by tubes to a compressing pump and to a pressure-guage. The pressure was measured by weights suspended so as to press directly on the valve of the gauge, over its centre, the relation between the pressure per square inch and the weight on the valve having been previously determined by a comparison with the pressure of a column of mercury fifty-two feet in height.

The precautions for the safety of the observer consisted in viewing the progress of compression through the strong plate glass eyes of a mask, and a small aperture in a plate of iron, interposed between them and the windows of the receiver.

The compression at pressures above 10,000 lbs. per square inch was ascertained by the use of the steel piezometer enclosed in a receiver of cast-steel, the motion of the piston being registered by the mark on the stem, as already explained.

At a pressure of 10,000 lbs. per square inch and temperature of 60° Fahr., the apparent compression of the oil, (disregarding that of the glass,) was 0·03059 its original volume being 1. At lower pressures, the compression indicated was nearly proportional to the pressure applied, though its rate decreases somewhat as the latter increases. This modification continues when the pressure is above 10,000 lbs. per square inch, but before it is raised to 20,000 lbs. per square inch, the degree of compression augments more rapidly than the pressure.

At 50° the compression of the oil was less regular in its ratio to the pressure employed, being greater as that was increased—suggesting the idea of the solidification of some of the more easily congealable portions of the oil.

To state at length all the considerations relative to the application of the piezometer which has been described, to the measurement of the pressure of fired gunpowder would extend this paper too far. It is however necessary to mention the influence of the change of temperature consequent on rapid condensation upon the amount of compression produced by any given force, the only circumstance, probably, modifying in an appreciable degree the correspondence between the pressure indicated by a stroke of the piezometer produced by slow compression, and that indicated by a mark of equal length produced by the action of fired gunpowder. When the compression is very slowly conducted, the change in the specific heat of the oil due to its condensation effects no observable alteration in its temperature, for it readily imparts its surplus heat to the bodies with which it is in contact. But if the compression be effected suddenly, any decrease in the specific heat of the liquid must be accompanied by a corresponding rise of temperature, and the compression produced in the latter case will be less, by the amount of the expansion which would, under that pressure, be

due to the elevation of temperature mentioned, than that produced by the same force slowly applied. The actual amount of this difference has not been ascertained, but data which lack the precision necessary to exact results, indicate that the correction due to this cause, which increases with both depression of temperature, and increase of pressure, is not unimportant. No attempt has been made however, to introduce this correction into the results subsequently presented of the experiments with the piezometer. The subject has been reserved in hope of future experiments, for which apparatus has been partially prepared.

In the fall of 1852 a piezometer was constructed on the plan which has been described, and was used, to test its working, for a few firings, in a 4 pdr. gun at Perth Amboy, N. J. In Feb., 1853, assistance was granted me from the U. S. Ordnance Department for testing my plan, and the subject was referred to Major Alfred Mordecai, with whom I had the pleasure and honor to be associated in making the experiments thus authorized, which, however, on account of various hindrances, were not undertaken until the winter of 1854–5.

Two six-pounder guns, one of iron and the other of brass, were used in the experiments. The diameter of the bore of each was, at the seat of the shot, 3·69 in., very nearly. The powder used was Dupont's cannon-powder, made in 1837. The shot were strapped to sabots of poplar (whitewood) of the full size of the bore unless otherwise specified. The firing was performed at Washington Arsenal, D. C. The oil used in the piezometer in all these experiments was of the same kind as that used in the experiments on compression, (unbleached winter-strained sperm oil,) being portions of the same mass.

In the first trials, the piezometer, covered with a case of paper to protect it from the heat attending the explosion, was attached by screwing to the bottom of the bore of the gun, occupying a place in the centre of the charge, but the screw was twice broken off, and this mode of using the instrument, which was originally adopted to avoid injuring the gun so as to render it unserviceable, was exchanged for the following.

The new piezometer was enclosed in a hollow plug of steel screwed into the side of the gun so that the cavity of the plug communicated with the bore of the gun. A leather case surrounded the instrument to protect it against injury from the shock of firing, and the remaining space within the cavity of the plug was filled with oil, which was retained by a disc of cork or leather loosely closing the communication with the bore. This arrangement was used in all the subsequent firing with cannon, and was entirely satisfactory. The length of the piezometer was 2·5 inches, its diameter 0·7 inch, and the diameter of its piston 0·252 in. The adjustment of the quantity of oil in

the instrument was made at the temperature at which the gun was fired. In the brass gun several holes were made for receiving the instrument at different distances (specified in the table) from the bottom of the bore. When not in use, these holes were closed by plugs fitted to each.

In the experiment with the musket barrel, a part of the breech-end, in the rear of the charge, was made to serve as a substitute for the cavity of the screw plug, in receiving the piezometer.

The experiments are to be regarded altogether as preliminary trials, but they are not, I hope, without interest and value. The following table presents the most interesting of the results.

Experiments on the pressure of fired Gunpowder.

GUN.	Powder. Weig't.	Powder. Height.	Shot. Weight, (strap'd)	Shot. Diam.	Dist'nce of piezomet'r fr m bott'm of bore.	Temperature of gun	Pressure pr. square inch.	Remarks.
	lbs.	in.	lbs.	in.	in.	Fahr.	lbs.	
Iron 6 pdr.	1·25	3·5	6 40	3 58	(3·25)	56° 5	9640	Piezomet'r attach'd to the bottom of the bore.
	"	"	6·32	"	"	54°	10140	
	"	3·42	6 33	"	1·5	55° 5	14260	Powder without cartridge bags.
	"	3 35	6·33	"	"	50°	16070	
	"	3·42	6·39	"	"	54°	149 .0	
	1·5	4·0	6 32	"	"	53°	17870	
	"	"	6·33	"	"	50°	18630	
	"	"	6·29	"	"	47°	17960	
Brass 6 pdr.	"	4·55	6 31	"	1	59°	20810	In this and subsequent firings, powder in cartr'ge bags.
	"	"	6 37	"	"	58°	20630	
	"	4·35	6 35	"	"	58°	19810	
	"	4·55	6 36	3·575	4	53°	16510	Mean of 3 rounds.
	"	"	6 34	"	7·8	50°	9575	Mean of 2 rounds.
	"	"	6·39	"	11·8	44°	7740	Mean of 3 rounds.
	"	"	6·38	"	15·8	52°	9570	" " "
	"	"	6·29	"	23·8	50°	8760	" " "
	"	"	6·33	"	31 8	"	6930	" " "
	"	"	6·36	"	39·8	"	5380	" " "
	"	"	6·34	"	47·8	"	5910	" " "
	"	4·48	6 11	"	1	"	16260	Mean of 2 rounds. Naked balls.
	"	4·65	0	...	"	"	5480	
	2·0	6 05	0	...	"	"	9780	
	3·0	8·8	0	...	"	"	14820	
	2·0	5·65	6·36	3·575	"	"	20640	Mean of 2 rounds.
	3 0	8·85	6·43	"	"	"	22220	
Iron 6 pdr.	1·5	4·38	12·16	3·66	1·5	"	20480	Cylinders equal to 2 balls.
	"	"	12·14	"	"	"	20780	" " "
	"	"	12·15	"	"	60°	20970	" " "
	grains.	in.	grs.	in.			lbs.	
Musket.	70	0·7	666	0·675	0	60°	2730	Expanding ball.
	110	1·18	420*	·65	0	"	3820	*Round ball and paper as for cartridge.
	310	3·55	464*	·675	0	"	15170	2d proof charge.
	389	4·2	" *	"	0	"	18500	1st proof charge.

In the first two experiments recorded in the preceding table the orifice of the piezometer was $3\frac{1}{4}$ inches from the bottom of

the bore, and was covered but ¼ inch deep with powder—the orifice facing toward the muzzle of the gun. The momentum of the gases rushing forward in the explosion seems to have relieved the instrument from a part of the pressure sustained by the sides of the bore at the same distance from the bottom.

The variations of pressure sustained by the gun when fired with charges very nearly the same, are greater, as might be expected, than the variations of initial velocity imparted to the ball under similar circumstances. When the combustion of the powder takes place with more than average rapidity the pressure in the first instants of the explosion is augmented, but its action on the ball is not so well sustained as in the case in which the combustion is more slow and consequently longer continued.

The following table of initial velocities of 6 pdr. balls, extracted from a table in Major Mordecai's "Second Report" of his experiments on gunpowder, will serve for the comparison.

Initial velocities of balls fired from a 6 pdr. gun.

Powder.		Shot.		Initial	
Weight.	Height	We ght.	Diam.	Velocity.	
lbs.	in.	lbs.	in.	ft.pr.sec'd.	
1·5	4 8	6·11	3·58	1594	
1·5	4·8	6·15	"	1580	
1·5	4·9	6·13	"	1553	
1·5		6 26	"	1538	Fixed ammunition.
1·5		6 37	"	1 98	
1·5		6·3	"	1520	

ART. XIII.—*Description of the Wax-paper process employed for the Photo-Meteorographic Registrations at the Radcliffe Observatory;* by WILLIAM CROOKES, Esq.*

1. BEFORE attempting to select from the numerous Photographic processes, the one best adapted to the requirements of Meteorology, it was necessary to take into consideration a number of circumstances, comparatively unimportant in ordinary operations.

To be of any value, the records must go on unceasingly and continuously:

1st. Therefore, the process adopted must be one combining sharpness of definition, with extreme sensitiveness, in order to mark accurately the minute and oftentimes sudden variations of the instruments.

* From the Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in the year 1854, under the superintendence of Manuel J. Johnson, M.A., Radcliffe Observer. Vol. XV. Oxford: 1856.

2nd. To avoid all hurry and confusion, it is of the utmost importance that the prepared paper or other medium, be of a kind capable of retaining its sensitiveness for several days.

3rd. The contraction which paper undergoes during the numerous operations to which it is subject in most processes, (in general rather an advantage than otherwise,) is here a serious objection; for this reason, the experiment first tried, of transferring to paper the image received on collodion preserved sensitive by the nitrate of magnesia process, was a failure.

4th. Strong contrast of light and shade, and absence of half tint, unfortunately so common amongst ordinary photographic pictures, is in this case no objection.

5th. It is essential to preserve the original results in an accessible form; and for this reason, the daguerreotype process, admirably as it seems to answer other requisites, is obviously not the one best suited to our purpose.

Lastly, the whole operation should if possible be so easily reducible to practice, that with a very small share of manipulatory skill, the loss of even a day's record would be impossible.

2. Bearing these conditions in mind, on looking over the photographic processes with which I was acquainted, that known as the wax-paper process, first described by M. Le-Gray, seemed peculiarly applicable. In sharpness it might be made to rival collodion; and although generally stated to be slow in its action, I had no doubt that its sensitiveness could be easily increased to the required degree.

Of all paper processes, I believed it to be one of the most free from contraction, either during the time it is undergoing the action of the light, or in any subsequent stage. Its chief superiority, however, consisted in its capability of remaining sensitive for so long a time, that it is of little consequence whether the sensitive sheets be a day or a week old. Then the comparative slowness of the development, which has always been looked upon as one of its weak points, would be in this case a positive advantage, as dispensing with that care and attention which must always be bestowed on a quickly developing picture.

In addition to all these recommendations, it was a process to which I had paid particular attention, and consequently the one in which I might naturally hope to meet with the greatest amount of success.

3. The general outline of the process does not differ materially from that which I published some years back in "Notes and Queries," vol. vi, p. 443; but as that account was written for practical photographers, the details of the manipulations were brief. It has therefore been thought advisable, that while describing again the whole process, with the addition of such modifications as the end in view requires, I should also give a fuller

description of the manipulation, as may render it more serviceable to those who have not hitherto paid attention to photography in its practical details. This must be my excuse, if to some I seem unnecessarily prolix. None but a practical photographer can appreciate upon what apparently trivial and unimportant points success in any branch of the art may depend.

It may not be without service, if, before entering into the practical details of the process, I say a few words respecting the most advantageous way of arranging a photographic laboratory, together with the apparatus, chemicals, &c., which are of most frequent use.

Among those requisites, which may be almost called absolute necessaries, are gas, and a plentiful supply of good water, as soft as can be procured.

4. The windows and shutters of the room should be so contrived as to allow of their either being thrown wide open for purposes of ventilation, or of being closed sufficiently well to exclude every gleam of daylight; and the arrangement should admit of the transition from one to the other being made with as little trouble as possible.

5. A piece of very deep orange-colored glass, about two feet square, should be put in the window, and the shutter ought to be constructed so as to allow of the room being perfectly darkened, or illuminated, either by ordinary daylight, or daylight which has been deprived of its photographic rays, by filtering through the orange glass. The absorbing power of this glass will be found to vary very considerably in different specimens, and I know of no rule but experience to find out the quality of any particular sample; the best plan is to select from a good stock one of as dark a color as possible. The proper color is opaque to the rays of the solar spectrum above the fixed line E.

6. The best source of heat is unquestionably gas. It will be as well, however, to have a fire-place in the room, as, in some cases, a gas stove will be inapplicable. There should be gas burners in different parts of the room for illumination at night; and also an arrangement for placing a screen of orange glass in front of each.

Several rough deal benches should be put up in different parts of the room, with shelves, drawers, cupboards, &c. The arrangement of these matters must of course depend upon the capabilities of the room.

7. The following apparatus is required. The quantities are those that we have found necessary in this Observatory.

Eight dishes.
Eight mill board covers.
Three brushes for cleaning dishes.
A vessel for melting wax.

Two gauze burners.
One box iron.
Filtering paper.
A still for water.
One platinum, and three bone spatulas, (flat paper knives).
Six funnels.
One funnel stand.
Pint, half pint, one ounce, and one drachm, measures.
Three glass flasks.
Boxes for holding paper.
Scales and weights.
Sponge, glass rods, stoppered bottles, &c.

8. The dishes may be made of glass, porcelain, or gutta percha. Glass and porcelain are certainly cleaner than gutta percha; but for general use the latter is far preferable, as with it there is no risk of breakage, and the bottom of the dish can be made perfectly flat, which is a great advantage. These dishes should be made of sufficient length to allow of a margin of about half an inch at each end when the paper is in; and the shape should be made as nearly square as possible, by arranging them to take two or three sheets side by side.

The gutta percha should be of a good thickness, otherwise it will bend and give way, if it be moved when full of liquid. The depth must depend upon the size of the dish, and the purpose for which it is intended. The dishes in use here accomodate three sheets of paper side by side; they are fifteen inches square, and one inch and a half deep. I think, however, for some purposes, where they are not wanted to be moved about much, (i. e. those for holding the bath of hyposulphite of soda for fixing,) the depth might be advantageously increased to two inches and a half. Each dish ought to be reserved for a particular solution, and should have a piece of mill board a little longer than itself for a cover.

9. The brushes for cleaning the dishes are of two sorts; a common scrubbing brush will be found the best for all parts but the corners, and for these another kind must be used, having a handle about a foot long, at the end of which are tufts of stiff bristles, projecting about three quarters of an inch, and radiating on all sides, forming a ball about two inches and a half in diameter. Hardly any dirt will be found capable of resisting this brush, if it be pressed into a corner, and twisted round several times. The dishes ought always to be put away clean, as the dirt is much more difficultly removed if allowed to dry on.

10. When a dish is to be cleaned, if it be of glass or porcelain, strong nitric acid must be poured into it; if of gutta percha, it should be filled with a strong solution of cyanid of potassium. After soaking for half an hour or an hour, according to the state

of the dish, the liquid is to be returned into the bottle, (both the nitric acid and the cyanid can be used several times,) the dish rinsed out with water, and then well scrubbed in every part with the brushes; afterwards it is to be washed several times in common water, once with distilled water, and then placed in a slanting position against a wall, face downwards, to drain on clean blotting paper.

11. The vessel in which the wax is melted, must be contrived so as never to allow of its reaching a higher temperature than 212° Fahr., or decomposition of the wax might ensue. I have found the most convenient apparatus to be, a tin vessel 15 inches square and 4 inches deep, having a tray which holds the wax fitting into it, about 1 inch deep. The under vessel is to be half filled with water, and by keeping this just at the boiling temperature, the wax above will soon become liquid.

12. The best source of heat is that known as the gauze gas burner, it being free from smoke or dust, and not liable to blacken anything placed over it. It consists of a common argand burner fixed on a rather low and heavy iron stand, which is surmounted by a copper or brass cylinder 5 inches in height and 2 inches wide, having a piece of wire gauze of 900 meshes to the square inch fastened over the top. By connecting this burner by means of vulcanised indian rubber tubing to the gas pipe, it can be moved about the table to any convenient position. The mixture of gas and air formed inside the cylinder, is to be lighted above the wire gauze; it burns over this with a large and nearly colorless but intensely hot flame.

13. The most convenient form of iron is the ordinary box iron, made hot by heaters inside; perhaps it might be improved in shape by having the end not quite so pointed, but this is not of much consequence. Some operators recommend facing the bottom with a plate of silver; this is very expensive, and seems to me to be attended with no advantage whatever.

14. For the purpose of absorbing the excess of wax from the surface of the sheet, I should recommend the ordinary white wove blotting paper, medium thickness. But this is not sufficiently free from impurities to serve either for drying the sensitive sheets, or for filtering; for this purpose, the fine filtering paper (not the Swedish) employed in quantitative chemical operations is the best.

15. The distilled water being one of those substances upon the purity of which success will in a great measure depend, it will be found much safer to distil it on the premises, especially as the quantity required is trifling. A convenient size for the still is about two gallons; it may be procured ready made, with worm &c. complete, of any large dealer in chemical apparatus. It will be found far more economical both in time and trouble,

to heat the water over a charcoal or coke fire, in preference to using gas for this purpose.

16. A platinum spatula is a most necessary instrument in almost every operation; the best size is 4 inches long, ½ an inch wide at one end, and ⅝ at the other, the corners being rounded off, it should be of a sufficient substance to prevent its being easily bent. Its chief use is, to raise one corner of the sheets to allow of their being held between the finger and thumb, for the purpose of removing from one dish to another, as, previous to fixing, none of the solutions should come in contact with the fingers.

During the fixing and subsequent washing, bone spatulas will be found very useful; but after having been in contact with hyposulphite of soda, they must be carefully kept away from any of the previous baths, or black stains will infallibly ensue.

17. The funnels may be either of glass or porcelain; it will be found useful to have several of different sizes, from two inches diameter, up to six inches. A convenient stand for them may be made of a piece of flat board, with circular holes, about half the diameter of the funnels employed, drilled into it, and supported upon four legs about eight inches high. The paper used for filtering should be the finest of the two sorts of blotting paper mentioned above (14). The filters can either be cut from the sheet as wanted, or they may be obtained ready cut in packets.

The measures should be of glass, graduated, the pint and half pint into ounces, the ounce measure into drachms, and the drachm measure into minims; they should be rather long in proportion to their width.

The Florence oil flasks, which can be obtained for a trifle at any warehouse, will be found to answer every purpose, nearly as well as the more expensive German flasks. They must be cleansed thoroughly from the adhering oil; this may be done by boiling in them, over the gauze gas burner, a strong solution of ordinary washing soda, and afterwards well rinsing out with water.

18. It will be found indispensable, where there are many operations going on at the same time, and many different sheets of paper in various stages of progress, to have a separate box or division to hold the paper in each of its stages. The plan I have found most convenient, is to obtain several mill-board boxes, the fronts of which will fall flat when the lid is lifted up, similar to those used by stationers for holding letter paper, &c.: they can be made to hold two or three piles of sheets side by side.

The scales and weights need not be of any great accuracy. A six inch beam capable of turning to half a grain, when loaded with 500 grains in each pan, will be all that is requisite; the

pans must be of glass, and the weights should consist of a set of grain and a set of drachm weights.

A sponge will be found useful for wiping up any of the solutions that may have been spilt on the bench. Solid glass stirring rods of about the thickness of a quill, and six or eight inches long, and a small wedgewood pestle and mortar, are of great service in many of the operations.

Stoppered bottles should be employed for all the solutions; and too much care cannot be taken to label each bottle accurately and distinctly.

19. Besides the above apparatus, the following materials and chemicals are requisite. A rough estimate is also given of their relative consumption in three months.

Photographic paper, 270 sheets, or 112 square feet.
Four pounds of wax.
Three ounces of iodid of potassium
Three ounces of bromid of potassium.
Four ounces of nitrate of silver.
Two ounces of glacial acetic acid.
Four ounces of gallic acid.
One pint of alcohol.
Seven pounds of hyposulphite of soda.
Half a pound of cyanid of potassium.
Half a pint of concentrated nitric acid.
Eighteen gallons of distilled water.

20. The selection of a good sample of paper for the basis on which the sensitive material is to be formed is of great importance, as any imperfection will be a source of annoyance in every stage of the process, and will hardly fail to show itself on the finished picture. The paper, which from numerous experiments I have found to be superior to any other, is that known as Canson's thin photographic paper. This is manufactured with great care, and is in general very uniform in quality.

It will be found by far the most advantageous plan, when used on a scale like the present, to order it of some wholesale stationer cut to the requisite dimensions. The size of the sheets in use here is $4\frac{5}{8}$ inches by $12\frac{1}{1}\frac{1}{2}$ inches*. Hitherto Messrs. Hallifax and Co. 319, Oxford Street, have supplied us with the paper of this size.

21. I am indebted to Mr. Barclay of Regent Street, wax bleacher, for much valuable information concerning wax and its adulterations, and for an extensive assortment of waxes of all

* This is a most inconvenient size, as it involves the cutting of more than one third of the paper to waste. The admirably ingenious arrangement of Mr. Ronald's, was not made with the view of employing Canson's paper; or it would doubtless have been contrived to accomodate sheets of a size which could be cut with less waste, such as $4\frac{1}{2}$ by 13 inches, or $4\frac{5}{8}$ by $11\frac{1}{2}$ inches.

kinds, and in every degree of purity: also to Mr. Maskelyne, for a valuable series of the chemical bodies of which the various waxes are composed; by means of these, I have been enabled to examine the effect produced by saturating the paper with bees wax from different countries, Myrica wax, Canauba wax, China wax, spermaceti, ethal, stearic acid, stearin, palmitic acid, palmitin, paraffin, and various oils.

22. I find that the action of the wax is purely mechanical, almost the only difference of effect produced by any of the above bodies, widely as they vary in their chemical nature, arising from a difference in their physical properties.

Stearin, palmitin, and most of the oils, are too greasy in their nature to be advantageously employed. The fatty acids do not make the paper in the least greasy, but they injure the transparency. China wax has almost too high a melting point, and gives a crystalline structure to the paper. Spermaceti also is too crystalline. Paraffin, ethal, and the waxes, produce very good results; of these bees wax is the only one that would be practically available for this purpose. It should be free from stearin, stearic acid, tallow, &c.; the presence of a little spermaceti does not much interfere, but as its price differs little from that of pure wax, it is not so common an adulteration as the other cheaper substances.

23. It will be unsafe to use the wax in the form of round thin tablets, about 4 inches in diameter, in which it is usually met with, as in this state it is generally adulterated to the extent of *at least* 50 per cent.

As an article of commerce, it is next to impossible to obtain small quantities of wax sufficiently pure to be relied upon. The only way I can recommend is to apply to one of the well known large bleachers, and trust to them for supplying the article in a state of purity. Whenever I have found it necessary to make such applications, my request has always been acceded to in the most cordial manner, and every information has been given with the utmost readiness.

24. The other chemicals, (with the exception of the strong nitric acid, which any retail druggist will supply, and the water, which had best be distilled on the premises,) should be ordered direct from some manufacturing chemist, as otherwise, unless the operator have a sufficient knowledge of chemistry to be able to detect any inferiority, there is danger of not having the articles sufficiently pure.

The iodid and bromid of potassium should be ordered *purified.*

The nitrate of silver should be crystallized, not in sticks; it ought to be perfectly dry, and have no smell, acid or otherwise.

There are usually two varieties of glacial acetic acid to be met with; the purest must be used; it should be perfectly free from

any empyreumatic odor, and must cause no turbidity when mixed with a solution of nitrate of silver, e.g. in making the exciting bath (42).

The gallic acid should be as nearly white in color as possible.

Especial care should be taken to have the alcohol good; it should be 60° over proof, and of specific gravity 0·83. On evaporating a few drops on the palm of the hand, no smell should be left behind, nor should it, under the same circumstances, leave any stain on a sheet of white paper.

25. The hyposulphite of soda will be found one of the articles most difficult to obtain pure; there is a large quantity at present in the market, having little else of the salt but the name, and is of course totally unfit for use; if there be the least doubt about its purity, it should be tested in the following manner:—

Weigh out accurately 10 grains of nitrate of silver, dissolve this in half an ounce of distilled water; then add 4 grains of chlorid of sodium (common salt) also dissolved in water. On mixing these two solutions together, a white curdy precipitate of chlorid of silver will fall down. Next add 22 grains of the hyposulphite of soda, and allow it to stand for about ten minutes, stirring occasionally with a glass rod. If at the end of that time the chlorid of silver has dissolved, the hyposulphite of soda may be considered as pure. A greater or less amount of residue will indicate roughly the degree of impurity.

26. The cyanid of potassium is usually met with in the form of hard white lumps; they will be found quite pure enough. It is very useful in removing stains formed by nitrate of silver on the fingers, &c., but the greatest care must be taken in its employment, as it is a most energetic poison; its use in cleaning the dishes from silver stains has been pointed out above (10).

27. The first operation to be performed is to make a slight pencil mark on that side of the photographic paper which is to receive the sensitive coating. If a sheet of Canson's paper be examined in a good light, one of the sides will be found to present a finely reticulated appearance, while the other will be perfectly smooth; this latter is the one that should be marked. Fifty or a hundred sheets may be marked at once, by holding a pile of them firmly by one end, and then bending the packet round, until the loose ends separate one from another like a fan; generally all the sheets lie in the same direction, therefore it is only necessary to ascertain that the smooth side of one of them is uppermost, and then draw a pencil once or twice along the exposed edges.

28. The paper has now to be saturated with white wax. The apparatus for this purpose has been previously described (11.) The wax is to be made perfectly liquid, and then the sheets of paper, taken up singly and held by one end, are gradually low-

ered on to the fluid. As soon as the wax is absorbed, which takes place almost directly, they are to be lifted up with rather a quick movement, held by one corner, and allowed to drain until the wax, ceasing to run off, congeals on the surface. When the sheets are first taken up for this operation, they should be briefly examined, and such as shew the water mark, contain any black spots,* or have any thing unusual about their appearance, should be rejected.

29. The paper in this stage will contain far more wax than necessary; the excess may be removed, by placing the sheets singly between blotting paper (14), and ironing them; but this is wasteful, and the loss may be avoided by placing on each side of the waxed sheet two or three sheets of unwaxed photographic paper, and then ironing the whole between blotting paper; there will generally be enough wax on the centre sheet to saturate fully those next to it on each side, and partially, if not entirely, the others. Those that are imperfectly waxed may be made the outer sheets of the succeeding set. Finally, each sheet must be separately ironed between blotting paper, until the glistening patches of wax are absorbed.

30. It is of the utmost consequence that the temperature of the iron should not exceed that of boiling water. Before using, I always dip it into water until the hissing entirely ceases. This is one of the most important points in the whole process, but one which it is very difficult to make beginners properly appreciate. The disadvantages of having too hot an iron, are not apparent until an after stage, while the saving of time and trouble is a great temptation to beginners. It is to a neglect of this point that I am inclined to attribute most of the faults so commonly laid to the charge of this beautiful process; such as gravelly appearance, or want of smoothness in the lights, and quick decomposition in the developing solution.

31. A well waxed sheet of paper, when viewed by obliquely reflected light, ought to present a perfectly uniform glazed appearance on one side, while the other should be rather duller; there must be no shining patches on any part of the surface, nor should any irregularities be observed on examining the paper with a black ground placed behind; seen by transmitted light, it will appear opalescent, but there should be no approach to a granular structure. The color of a pile of waxed sheets is slightly bluish.

32. The paper, having undergone this preparatory operation, is ready for *iodizing;* this is effected by completely immersing it in an aqueous solution of an alkaline iodid, either pure or mixed with some analogous salt.

* These spots have been analyzed by Mr. Malone; he finds them to consist, not of iron, as is generally supposed, but of small pieces of brass. I have also examined them myself with a like result.

One would think that in no part of the photographic operation, would greater unanimity exist, than on the composition of the iodizing bath; but on this subject, strangely enough, no two persons seem to think alike. The formulæ for this bath are nearly as numerous as the operators themselves, and some of them show not a little ingenuity in the manner in which substances apparently the most unphotographic have been pressed into service.

33. The results of numerous experiments, which I need not mention here, had convinced me, that for ordinary purposes, iodid of silver *per se* was the best sensitive surface for receiving an image in the Camera; but on making use of that body in these operations, (by employing pure iodid of potassium in the bath,) I was surprised to meet with results, for which I was at first unable to account. A little consideration, however, showed me the direction in which I was to look for a remedy. The experiments which had led me to prefer iodid of silver as a sensitive surface, had all been performed with sunlight, either direct, or more frequently in the form of diffused daylight. In this case, however, coal gas was the source of light; and if, as was very probable, there were any great difference in the quality of the light from these two sources, the superiority of iodid over the bromid or chlorid of silver would still be a matter for experiment.

34. A comparison of the spectra of the two kinds of light showed a very marked difference; while in sunlight the spectral rays which are around and above the fixed line G, (the indigo and higher rays) are so intense and numerous, as completely to overpower the small space between and about F and G, (the blue and upper portion of the green,) a part of the spectrum which affects bromid more than iodid of silver; in gaslight, the case was quite different. The great bulk of photographic rays was found to lie within the limits of the visible spectrum, and consequently the photographic action of this light was likely to be far more energetic on bromid than on iodid of silver. These suppositions were fully borne out by experiment: on introducing a little bromid of potassium into the iodizing bath, the change was very apparent. It requires a certain proportion to be observed between the two to obtain the best results. If the iodid of potassium be in excess, the resulting silver salt will be wanting in sensitiveness, requiring a comparatively long development to render an image visible; while, if the bromid be in excess, there will be a great want of vigor in the impression, the picture being red and transparent. When the proportion between the two is properly adjusted, the paper will be extremely sensitive, the picture presenting a vigorous black appearance, without the least approach to red. The addition of a chlorid was found to

produce a somewhat similar effect to that of a bromid, but in a less marked degree. As no particular advantage could be traced to it, it was not employed.

35. I have also tried most of the different forms of organic matter, which it is customary to add to this bath, but I cannot recommend them; the most that can be said is, that some of them do no harm. At first I thought a little isinglass might be an improvement, as it instantly removes the greasiness from the surface of the paper, and allows the iodid of potassium to penetrate more readily. Unfortunately, however, it interferes with the most important property of this process, that of remaining sensitive for a long time.

36. I think the best results are obtained, when the iodid and bromid are mixed in the proportion of their atomic weights; the strength being as follows:

Iodid of potassium . . .	582·5 grains.
Bromid of potassium . .	417·5 grains.
Distilled water	40 ounces.*

When the two salts have dissolved in the water, the mixture should be filtered; the bath will then be fit for use.

37. At first, a slight difficulty will be felt in immersing the waxed sheets in the liquid without enclosing air bubbles, the greasy nature of the surface causing the solution to run off. The best way is to hold the paper by one end, and gradually to bring it down on to the liquid, commencing at the other end; the paper ought not to slant towards the surface of the bath, or there will be danger of enclosing air bubbles; but while it is being laid down, the part out of the liquid should be kept as nearly as possible perpendicular to the surface of the liquid; any curling up of the sheet when first laid down, may be prevented by breathing on it gently. In about ten minutes, the sheet ought to be lifted up by one corner, and turned over in the same manner; a slight agitation of the dish will then throw the liquid entirely over that sheet, and another can be treated in like manner.

38. The sheets must remain soaking in this bath for about three hours; several times during that interval, (and especially if there be many sheets in the same bath,) they ought to be moved about and turned over singly, to allow of the liquid penetrating between them, and coming perfectly in contact with every part of the surface. After they have soaked for a sufficient time, the sheets should be taken out and hung up to dry; this is conveniently affected by stretching a string across the

* While giving the above as the calculated quantities, I do not wish to insist upon their being adhered to with any extreme accuracy. An error of a few grains on either side would I believe be without any perceptible effect on the result.

room, and hooking the papers on to this by means of a pin bent into the shape of the letter S. After a sheet has been hung up for a few minutes, a piece of blotting paper, about one inch square, should be stuck to the bottom corner to absorb the drop, and prevent its drying on the sheet, or it would cause a stain in the picture.

39. While the sheets are drying, they should be looked at occasionally, and the way in which the liquid on the surface dries, noticed; if it collect in drops all over the surface, it is a sign that the sheets have not been sufficiently acted on by the iodizing bath, owing to their having been removed from the latter too soon. The sheets will usually during drying assume a dirty pink appearance, owing probably to the liberation of iodine by ozone in the air, and its subsequent combination with the starch and wax in the paper. This is by no means a bad sign, if the color be at all uniform; but if it appear in patches and spots, it shows that there has been some irregular absorption of the wax, or defect in the iodizing, and it will be as well to reject sheets so marked.

40. As soon as the sheets are quite dry, they can be put aside in a box for use at a future time. There is a great deal of uncertainty as regards the length of time the sheets may be kept in this state without spoiling; I can speak from experience as to there being no sensible deterioration after a lapse of ten months, but further than this I have not tried.

Up to this stage, it is immaterial whether the operations have been performed by daylight or not; but the subsequent treatment, until the fixing of the picture, must be done by yellow light (5).

41. The next step consists in rendering the iodized paper sensitive to light. Although, when extreme care is taken in this operation, it is hardly of any consequence when this is performed; yet in practice, it will not be found convenient to *excite* the paper earlier than about a fortnight before its being required for use. The materials for the exciting bath are nitrate of silver, glacial acetic acid, and water. Some operators replace the acetic acid by tartaric acid; but as I cannot perceive the effect of this change except in a diminution of sensitiveness, I have not adopted it. It is of little importance what be the strength of the solution of nitrate of silver; the disadvantages of a weak solution are, that the sheets require to remain in contact with it for a considerable time before the decomposition is effected, and the bath requires oftener renewing; while with a bath which is too strong, time is equally lost in the long-continued washing requisite to enable the paper to keep good for any length of time. The quantity of acetic acid is also of little consequence.

42. In the following bath, I have endeavored so to adjust the proportion of nitrate of silver, as to avoid as much as possible both the inconveniences mentioned above,

Nitrate of silver	300 grains.
Glacial acetic acid	2 drachms.
Distilled water	20 ounces.

The nitrate of silver and acetic acid are to be added to the water, and when dissolved, filtered into a clean dish (10), taking care that the bottom of the dish be flat, and that the liquid cover it to the depth of at least half an inch all over; by the side of this, two similar dishes must be placed, each containing distilled water.

43. A sheet of iodized paper is to be taken by one end, and gradually lowered, the marked side downwards, on to the exciting solution, taking care that no liquid gets on to the back, and no air bubbles are enclosed.

It will be necessary for the sheet to remain on this bath from five to ten minutes; but it can generally be known when the operation is completed by the change in appearance, the pink color entirely disappearing, and the sheet assuming a pure homogeneous straw color. When this is the case, one corner of it must be raised up by the platinum spatula, lifted out of the dish with rather a quick movement, allowed to drain for about half a minute, and then floated on the surface of the water in the second dish, while another iodized sheet is placed on the nitrate of silver solution; when this has remained on for a sufficient time, it must be in like manner transferred to the dish of distilled water, having removed the previous sheet to the next dish.

44. A third iodized sheet can now be excited, and when this is completed, the one first excited must be rubbed perfectly dry between folds of clean blotting paper (14), wrapped up in clean paper, and preserved in a portfolio until required for use; and the others can be transferred a dish forward, as before, taking care that each sheet be washed twice in distilled water, and that at every fourth sheet the dishes of washing water be emptied, and replenished with clean distilled water; this water should not be thrown away, but preserved in a bottle for a subsequent operation (49).

45. The above quantity of the exciting bath, will be found quite enough to excite about fifty sheets of the size here employed, or 3000 square inches of paper. After the bulk has been exhausted for this purpose, it should be kept, like the washing waters, for the subsequent operation of developing (49).

Of course these sensitive sheets must be kept in perfect darkness. Generally, sufficient attention is not paid to this point. It should be borne in mind, that an amount of white light, quite harmless if the paper were only exposed to its action for a few

minutes, will infallibly destroy it if be allowed to have access to it for any length of time; therefore, the longer the sheets are required to be kept, the more carefully must the light, even from gas, be excluded; they must likewise be kept away from any fumes or vapor.

46. Experience alone can tell the proper time to expose the sensitive paper to the action of light, in order to obtain the best effects. However, it will be useful to remember, that it is almost always possible, however short the time of exposure, to obtain some trace of effect by prolonged development. Varying the time of exposure, within certain limits, makes very little difference on the finished picture; its principal effect being to shorten or prolong the time of development.

Unless the exposure to light has been extremely long, (much longer than can take place under the circumstances we are contemplating,) nothing will be visible on the sheet after its removal from the instrument, more than there was previous to exposure; the action of the light merely producing a latent impression, which requires to be developed to render it visible.

47. The developing solution in nearly every case consists of an aqueous solution of gallic acid, with the addition, more or less, of a solution of nitrate of silver.

An improvement on the ordinary method of developing with gallic acid, formed the subject of a communication to the Philosophical Magazine for March, 1855, where I recommend the employment of a strong alcoholic solution of gallic acid, to be dilluted with water when required for use, as being more economical both of time and trouble than the preparation of a great quantity of an aqueous solution for each operation.

48. The solution is thus made: put two ounces of crystallized gallic acid into a dry flask with a narrow neck; over this pour six ounces of good alcohol, (60° over proof,) and place the flask in hot water until the acid is dissolved or nearly so. This will not take long, especially if it be well shaken once or twice. Allow it to cool, then add half a drachm of glacial acetic acid, and filter the whole into a stoppered bottle.

49. The developing solution which I employ for one set of sheets, or 180 square inches, is prepared by mixing together ten ounces of the water that has been previously used for washing the excited papers (44), and four drachms of the exhausted exciting bath (45); the mixture is then filtered into a perfectly clean dish, and half a drachm of the above alcoholic solution of gallic acid poured into it. The dish must be shaken about until the greasy appearance has quite gone from the surface; and then the sheets of paper may be laid down on the solution in the ordinary manner with the marked side downwards, taking particular care that none of the solution gets on the back of the paper, or it will

cause a stain. Should this happen, either dry it with blotting paper, or immerse the sheet entirely in the liquid.

50. If the paper has been exposed to a moderate light, the picture will begin to appear within five minutes of its being laid on the solution, and will be finished in a few hours. It may however sometimes be requisite, if the light has been feeble, to prolong the development for a day or more. If the dish be perfectly clean, the developing solution will remain active for the whole of this time, and when used only for a few hours, will be quite clear and colorless, or with the faintest tinge of brown; a darker appearance indicates the presence of dirt. The progress of the development may be watched, by gently raising one corner with the platinum spatula, and lifting the sheet up by the fingers. This should not be done too often, as there is always a risk of producing stains on the surface of the picture. I prefer allowing the development to go on, until the black is rather more intense than ultimately required, as it is generally toned down in the fixing bath.

51. As soon as the picture is judged to be sufficiently intense, it must be removed from the gallo-nitrate, and laid on a dish of water, (not necessarily distilled). In this state it may remain until the final operation of fixing, which need not be performed immediately, if inconvenient. After being washed once or twice, and dried between clean blotting paper, the picture will remain unharmed for weeks, if kept in a dark place.

52. The *fixing bath* is composed of a saturated solution of hyposulphite of soda diluted with its own bulk of water. Into this the sheets are to be completely immersed, until the whole of the yellow iodid of silver has been dissolved out. This operation need not be performed by yellow light; daylight is much bettter for shewing whether the picture be entirely fixed. This will take from a quarter of an hour to two hours, according to the time the bath has been in use.

It will be well not to put too many sheets into the bath at once, in order to avoid the necessity of turning them over to allow the liquid to penetrate every part.

When fixed, the sheet if held up between the light and the eye, will present a pure transparent appearance in the white parts.

The fixing bath gradually becomes less and less active by use, and then its action is very energetic on the dark parts of the picture, attacking and dissolving them equally with the unchanged iodid. When this is the case it should be put on one side, (not thrown away,) and a fresh bath made.

53. After removal from the fixing bath, the sheets must be well washed. In this operation, the effect depends more upon the quantity of water used, than upon the duration of the immer-

sion. When practicable it is a good plan to allow water from a tap to flow over the sheets for a minute or two, and having thus got rid of the hyposulphite of soda from the surface, to allow them to soak for about ten minutes in a large dish of hot water.

54. They are then to be dried by hanging up by a crooked pin, as after iodizing. When dry, they will present a very rough and granular appearance in the transparent parts; this is removed by melting the wax, either before a fire, or, what is far better, by placing them between blotting paper, and passing a warm iron over them; by this means, the white parts will recover their original transparency.

55. The picture, arrived at this stage, may be considered finished, as far as is requisite for the purposes of measurement and registration; sometimes, however, it may be necessary to multiply copies, for the purpose of transmitting to other Meteorological Observatories facsimiles of the records, or at least of those containing any remarkable phenomena. I will therefore now detail the method of printing photographic positives from these negatives, premising that the process does not differ materially from that usually adopted.

56. The only extra piece of apparatus required, is a *pressure frame;* which consists essentially of a stout piece of plate glass in a frame, with an arrangement for screwing a flat board, the size of the glass, tight against it. Though apparently very simple, some care is required, when the frame is a large one, in arranging the screw and board at the back, so as to obtain an equal pressure all over the surface; unless this is done, the glass will be very liable to break. The pressure frames supplied to us by Messrs Newman and Murray, 122, Regent Street, are unexceptionable in this respect. The board should of course be well padded with velvet, and the lateral dimensions of the glass should be the same as those of the gutta percha dishes (8).

57. The extra chemicals required for this process, are chlorid of sodium, and chlorid of gold. Generally speaking, for the former, common table salt will be found quite pure enough; but as the quantity required is but small, it will perhaps be found better to obtain some of the recrystallized salt along with the other chemicals.

The chlorid of gold is merely required for an artistic effect. Many persons object to the reddish brown appearance of ordinary photographic positives; the addition of a little chlorid of gold to the fixing bath converts this into a rich brown or black; the trifling quantity required removes any objection to its use on the score of expense.

58. I prefer using the same kind of paper for positives as for negatives (20). Messrs Canson manufacture a thicker paper, which is generally called positive paper, but I think the thin is

far preferable; the surface is smoother, and the various solutions penetrate much better.

59. The first operation which the paper has to undergo is *salting*: the bath for this purpose consists of

Chlorid of sodium	100 grains
Distilled water	40 ounces.

Filter this into a clean dish, and completely immerse the sheets, marked as directed (27). This is best done by laying them gently on the surface of the liquid, and then pressing them under by passing a glass rod over them; as many sheets as the dish will hold may be thus immersed one after the other. Allow them to soak for about ten minutes, then lift and turn them over in a body; afterwards they may be hung up to dry (38), commencing with the sheet which was first put in. When dry, they may be taken down and put aside for use at any future time. The sheets in drying generally curl up very much; it will therefore be found convenient in the next process, if the salted sheets, before being put away, have been allowed to remain in the pressure frame, tight, for about 24 hours. This makes them perfectly flat.

60. The exciting bath is composed of

Nitrate of silver	150 grains.
Distilled water	10 ounces.

After filtering, pour the solution into a clean dish; and then lay the sheets, salted as above, on the surface, face downwards, gently breathing on the back, if it be necessary, to counteract the tendency to curl up; let them remain on this bath for about 10 minutes, and then hang up to dry (38).

61. This exciting bath will serve for nearly 100 sheets; it will then be better to put it on one side (64), and make a new bath. It is not advisable to excite more positive sheets than will be likely to be required in the course of a week, for they gradually turn brown by keeping, even in the dark, and lose sensitiveness. They will, however, keep much better, if pressed tight in the pressure frame, and thus protected from the air.

62. When a positive is to be printed from a negative, let the glass of the pressure frame be perfectly cleansed and free from dust on both sides, then lay the negative on it, with its back to the glass. On it place a sheet of positive paper, with its sensitive side down. Then, having placed over, as a pad, several sheets of blotting paper, screw the back down with sufficient force to press the two sheets into close contact, but of course not so as to endanger the glass. Now place the frame in the sun, so that the light can fall perpendicularly on the glass, and allow it to remain there until it is judged to have been exposed long enough.

63. No rule can be laid down for the proper time of exposure; it will depend upon the quality of the light, and intensity of the negative; some pictures being completed in a few minutes, others requiring upwards of half an hour. The printing should always go on until the picture is several shades darker than ultimately required. A very little experience will enable the operator to judge so well of the quality of the light, as hardly ever to have a failure. If the two sheets of paper be stuck together in two or three places at the edges with small pieces of gummed paper, the frame can be removed to the dark room, and the progress of the sheets examined; but this is always attended with some danger, for unless they are replaced without having been shifted one from the other, there will be a double image.

64. As soon as the picture is considered to be printed sufficiently deep, it has to be fixed.

The fixing bath consists of

Saturated solution of hyposulphite of soda	10 ounces.
Water	30 ounces.

This bath will be found to fix the pictures perfectly, but they will generally be of a reddish tint; if it be thought desirable to obtain the pictures of some shade of dark brown, or black, it will be necessary to employ a bath made as follows;

Saturated solution of hyposulphite of soda	10 ounces.
Water.	10 ounces.
Exhausted positive exciting solution (61)	10 ounces.

Mix these together and then add the following;

Water	10 ounces,
Chlorid of gold	20 grains;

taking care in mixing to pour the solution of gold into the solution of hyposulphite, and not the latter into the former, or another decomposition will be produced.

Pour this mixture into a dish, and lay the positive carefully on it, face downwards. As soon as it is thoroughly damp, (which may be known by its becoming perfectly flat after having curled up,) immerse it totally in the liquid.

65. The pictures should not be too crowded in the bath, as they are very apt to become irregularly colored in places where the hyposulphite has not had free access during the whole of the time. When first put in, the color will change to a light brown, and in the course of some time, varying from ten minutes to two or three hours, it will pass through the different shades of brown to black and purple, gradually fading in intensity during the time. It will be necessary to allow the picture to remain in this bath for ten minutes *at least* in order that it may be perfectly

fixed. After this time, its stay need only be prolonged until it has become of the desired tone and color; always remembering, that during the subsequent operation of drying, &c., it will become of a somewhat darker tint than when taken out of the fixing bath.

66. On removal from this bath, the pictures must be allowed to soak in a large quantity of cold water for ten or twelve hours. There must not be very many in the dish at a time, and the water must be changed at least three times during that interval; they must then have boiling water poured over them (of course in a *porcelain* dish) two or three times, and lastly pressed dry, between sheets of clean blotting paper (14), (these may be used several times, if dried,) and then allowed to dry spontaneously in the air. When the pressure frame is not in use, a pile of these finished positives may be put in, and kept tightly screwed up all night; by this means they will be rendered perfectly flat and smooth.

67. The picture is now complete. It must be borne in mind, however, that the light and shade are reversed by this operation, the track of the luminous image along the paper being represented by a *white* instead of by a *black* band, as in the original negative. Should it be desired to produce exact facsimiles of the negatives, it can be done by employing one of these positives as a negative, and printing other positives from it; in this way, the light and shade having been twice reversed, will be the same as in the original negative.

68. In some cases it may happen, that owing to a partial failure of gas, or imperfection in the sensitive sheet, an image may be so faint as to render it impossible to print a distinct positive. The gap that this would produce in a set of pictures may be obviated, and with very slight sacrifice of accuracy, by forming an artificial or *secondary* negative in the following manner:

69. Print a copy on positive paper, of any intensity which will show the most distinct impression; then without fixing, and with a pair of sharp scissors, accurately and carefully cut out the part corresponding to the impressed portion of the negative. Expose this piece to the light until it has become perfectly opaque, and then it can either be cemented over the imperfect original sheet, or on a clean sheet of paper, and used as an ordinary negative.

It is astonishing what accuracy and quickness in cutting even the most intricate pictures, may be obtained with a little practice; the error of the scissors is generally within the error of measurement.

Art. XIV.—*On a Zeolitic mineral (allied to Stilbite) from the Isle of Skye, Scotland;* by J. W. Mallet, Ph.D.

The specimen to which the following description refers has been in my possession for several years, and has attached to it a label bearing the name "Hypostilbite," but analysis shows it to be a mineral quite distinct from Beudant's hypostilbite of the Faroe Islands, and differing also from both stilbite proper and epistilbite.

It occurs as a mass of minute crystals, resembling white loaf sugar, breaking easily, and crushing under the fingers into a coarsish crystalline powder. The separate grains viewed under the microscope appear as single prismatic crystals or little groups of three or four, nearly transparent, colorless, and with a pearly lustre, especially on two opposite faces,—closely resembling stilbite in fact in general appearance.

The crystalline form could not be satisfactorily made out, but seemed to be monoclinic. Hardness a little greater than that of calcite. Specific gravity =2·252.

Strong muriatic acid poured over the pulverized mineral at night had the next morning formed a distinct jelly.

On analysis the following results were obtained.

		Atoms.
Silica,	53·95	1·191—3·
Alumina,	20·13	·392—1·
Lime,	12·86	·459—1·17
Magnesia,	trace	
Potash (with a little soda),	·87	
Water,	12·42	1·380—3·52
	100·23	

Neglecting the small quantity of alkali, these numbers lead us nearly to the formula,

$$2(CaO, SiO_3)+2(Al_2O_3, 2SiO_3)+7HO,$$

which differs completely from that of stilbite, $CaO, SiO_3+Al_2O_3, 3SiO_3+6HO$, or that of epistilbite, $CaO, SiO_3+Al_2O_3, 3SiO_3+5HO$. The percentage of water is also far too small for hypostilbite.

The mineral appears to be a distinct one, and does not seem to have resulted from the gradual decomposition or change of any other; but it is perhaps scarcely desirable to add to the already numerous names of stilbite-like minerals by adopting a new one for this substance until additional analyses of these nearly related species shall permit of their more accurate classification.

ART. XV.—*On the Application of the Mechanical Theory of Heat to the Steam Engine;* by R. CLAUSIUS.

[Translated for this Journal from Pogg. Ann. xcviii, 441, by W. G.]*

1. As the change in our views on the nature and relations of heat which is now comprised under the name of the "mechanical theory of heat," had its origin in the recognized fact that heat may be employed in producing mechanical work, we might *a priori* expect that, conversely, the theory which was originated in this way would contribute to put this application of heat in a clearer light. In particular the more general points of view obtained in this way should render it possible to form a certain judgment on the particular machines which serve for this application, whether they already perfectly answer their purpose, or whether, and how far, they are susceptible of improvement.

To these principles, which hold good for all thermodynamic machines, there are to be added for the most important of them—the steam engine—some particular ones which incite us to submit it to a new investigation deduced from the mechanical theory of heat. Some important deviations from the laws which were formerly assumed as correct, or at least applied in calculation, have been found to hold good precisely for steam at its maximum density.

2. In this particular I believe that I must first remind the reader that it has been proved by Rankine and myself, that when a quantity of steam, originally at its maximum density, expands in a shell which is impermeable to heat, by pushing back with its full expansive force a movable portion of the shell, as for instance a piston, a portion of the steam must be precipitated as water, while in most previous writings on the steam engine, and among others in the excellent work of de Pambour,† the principle of Watt, that under these circumstances the steam remains precisely at its maximum density, is assumed as the basis of the reasoning.

Furthermore, in the want of accurate knowledge, it was formerly assumed, in determining the volume of the unit of weight of saturated steam at different temperatures, that steam even at its maximum density still obeys the laws of Mariotte and Gay Lussac. In opposition to this I have already shewn in my first memoir on this subject,‡ that we may calculate the volumes which a unit of weight of steam assumes at different temperatures at its maximum density, from the fundamental principles of the mechanical theory of heat, by means of the collateral assumption, *that a permanent gas when it expands at a constant temperature ab-*

* The importance of this memoir induces us to give it *in extenso* instead of attempting an abstract, which would scarcely do it justice.—W. G.

† Theorie des machines á vapeur, par le Conte F. M. G. de Pambour. Paris, 1844.

‡ Pogg. Ann., lxxix, 368.

sorbs only so much heat as is consumed in doing the external work performed, and that we find in this way many values which, at the higher temperatures at least, deviate considerably from the laws of Gay Lussac and Mariotte.

This view of the behavior of steam was not shared at that time even by authors who occupied themselves specially with the mechanical theory of heat. W. Thomson in particular contested the point. He found—even a year later in a memoir laid before the Royal Society of Edinburg—in this result, only a proof of the improbability of my collateral assumption. More recently however, he has himself, associated with J. P. Joule, undertaken to test the correctness of this assumption experimentally. They have in fact found by a series of well devised experiments conducted upon a large scale, that the assumption is so nearly correct for the permanent gases examined by them, namely, atmospheric air and hydrogen, that the variations may in most calculations be neglected. They found, however, greater variations for the non-permanent gas, carbonic acid, which they also studied. This corresponds entirely with the remark, which I added to the first mention of the assumption, that it is probably true for every gas precisely in the degree in which the laws of Mariotte and Gay Lussac find their application to the same gas. In consequence of these experiments, Thomson has now also calculated the volume of saturated steam in the same way as myself. I believe therefore that the correctness of this mode of calculation will gradually be more and more fully recognized by other physicists also.

3. These two examples will suffice to shew that the fundamental principles of the former theory of the steam engine have undergone such important changes through the mechanical theory of heat that a new investigation of the subject is necessary.

In the present memoir I have made the attempt to develop the principles of a calculation of the work of the steam engine, corresponding with the mechanical theory of heat, in which however I have confined myself to the usual forms of the steam engine without at present entering upon the more recent attempts—certainly well worthy of consideration—to apply steam in an overheated state.

In setting forth this investigation I shall only suppose as known my last published memoir* "On an altered form of the second principal theorem of the mechanical theory of heat." It is true that it will in this way be necessary to deduce a second time in a somewhat different manner some results which are no longer new, but which were obtained at an earlier period by other writers or by myself; I believe however, that this repetition will be justified by the greater unity and clearness of the whole.

I shall refer in the proper places to the papers in which these results were first communicated, as far as they are known to me.

* Pogg. Ann., xciii, 481.

4. The expression that *heat drives a machine*, is of course not to be immediately referred to the heat, but is to be understood as signifying that some substance present in the machine, in consequence of the changes which it undergoes by heat, sets the parts of the machine in motion. We will call this substance the heat-utilizing substance (*den die Wirkung der Wärme vermittelnden Stoff*).

If now a continually acting machine be in uniform action, all the changes which occur take place periodically, so that the same condition in which the machine, with all its single parts, is found at a particular time, regularly recurs at equal intervals. Consequently the heat-utilizing substance must be present in the machine in equal quantity at such regularly recurring instants and must be in a similar condition. This condition may be fulfilled in two different ways.

In the first place, one and the same quantity of this substance originally existing in the machine may always remain in it, in which case the changes of condition which the substance undergoes during the action of the machine must take place in such a manner that at the end of every period it again returns to its initial condition, and then begins again the same cycle of changes.

In the second place, the machine may each time give off, externally, the substance which has served during one period to produce the action, and in its place may take up again from without the same quantity of substance of the same kind.

5. This last process is the more usual one in machines applied in practice. It occurs, for instance, in the caloric air machines constructed up to the present time, inasmuch as after every stroke the air which has moved the piston in the cylinder is driven into the atmosphere, and an equal quantity of air is supplied from the atmosphere, through the feeding cylinder. The same is the case in steam engines without condensers in which the steam passes from the cylinder into the atmosphere, while, to supply its place, a fresh portion of water is pumped from a reservoir into the boiler.

Furthermore, at least a partial application is also made in steam engines with condensers of the usual arrangement. In these the water condensed from the steam is partly pumped back into the boiler, but not wholly, because it is mixed with the cold water used for condensation, and a portion of this consequently also passes into the boiler. The portion of the condensed water not again applied must be thrown out with the rest of the water of condensation.

The first process has recently been applied in those steam engines which are worked by two different vapors, as for instance by water and the vapor of ether. In these the steam is condensed only by contact with the metallic tubes which are inter-

nally filled with liquid ether and is then completely pumped back into the boiler. In like manner the ether vapor is condensed in metallic tubes which are only externally surrounded by cold water, and is then pumped back into the first mentioned space which serves for the evaporation of the ether. In order to keep up a uniform action, therefore, it is only necessary to add as much water or ether as escapes through the joints from imperfections in the construction.

6. In a machine of this kind in which the same mass is always employed anew, the different changes which the mass undergoes during a period, must, as mentioned above, form a closed cycle, or according to the nomenclature which I have chosen in my former paper, a *circular process* (kreisprocess). Those machines, on the other hand, in which a periodical taking up and throwing out of masses occurs, are not necessarily subject to this condition. They may however also fulfill it when they separate the masses again in the same condition in which they have taken them up.

This is the case with steam engines with condensers, in which the water is thrown out from the condenser in the liquid state, and with the same temperature with which it passed from the condenser into the boiler.*

In other machines the condition at the exit is different from that at the entrance. The caloric air machines, for instance, even when they are provided with regenerators, force the air into the atmosphere with a higher temperature than it previously had, and the steam engines without condensers take up the water as a liquid and let it pass out again as a vapor. In these cases, no complete circular process takes place, it is true; nevertheless we may always imagine a second machine joined to that which is really present, which takes up the mass from the first machine, brings it in any way into the initial condition, and then first lets it escape. The two machines together may then be regarded as a single machine which again satisfies the above condition. In many cases this completion may be performed without producing thereby too great a complication of the investigation. Thus for instance we may imagine a steam engine without condenser, replaced by one with a condenser whose temperature is 100°, if we only assume that the first is fed with water at 100°.

Hence it appears that, upon the supposition that the machines which do not in themselves fulfill the condition, may in this way be completed for the purpose of investigation, we may apply to all thermo-dynamic machines the theorems which hold good for the circular process, and in this way we arrive at some conclusions which are quite independent of the particular nature of the processes taking place in the several machines themselves.

* The cooling water which passes into the condenser cold and out of it warm, is not here taken into consideration, since it does not belong to the heat-utilizing substance, but serves only as a negative source of heat.

7. I have represented in my former memoir the two principal theorems which hold good for every circular process, by the following equations.

$$(\text{I}) \qquad Q = A \cdot W$$

$$(\text{II}) \qquad \int \frac{dQ}{T} = -N,$$

in which the letters have the same signification as they have there, namely—

A is the equivalent of heat for the unit of work.

W represents the external work done during the circular process.

Q signifies the heat communicated to the changeable body during the circular process, and dQ an element of the same by which a quantity of heat taken from the body is considered as negative communicated heat. The integral of the second equation extends over the whole quantity Q.

T is a function of the temperature which the variable body has at the moment at which it takes up the element of heat dQ, or, should this body have different temperatures in its different parts, of the temperature of the part which takes up dQ. As to the form of the function T, I have shewn in my previous memoir that it is probably nothing else than the temperature itself, when this is estimated from the point which is determined by the reciprocal value of the coefficient of expansion of an ideal gas, and which must lie in the neighborhood of $-273°$ C., so that when the temperature estimated from the freezing point is denoted by t, we have

$$(1) \qquad T = 273 + t.$$

In future I shall employ the magnitude T always with this signification, and call it briefly the absolute temperature, remarking however that the conclusions arrived at do not in their essence depend upon this assumption, but remain valid even if we regard T as a still undetermined function of the temperature.

Finally, N signifies the equivalent value of all the uncompensated changes occurring in the circular process.*

* A species of uncompensated transformations requires here a special notice. The sources of heat which are to communicate heat to the variable body must have higher temperatures than this last, and conversely those which are to communicate to it negative heat. or to take away heat from it, must have lower temperatures. At every exchange of heat between the variable body and a source of heat, there is an immediate passage of heat from a body of a higher temperature to one of a lower temperature, and herein lies an uncompensated transformation which is so much the greater, the more different the two temperatures are. Whether these uncompensated transformations, in the determination of which not only the changes of condition of the variable body, but also the temperatures of the sources of heat applied come into consideration, are embraced in N or not, depends upon the signification which we attribute to the temperature occurring in equation (II). If we understand by this the temperature of the *source of heat* belonging to the element dQ, these transformations are included in N. If however we understand by it as is above determined, and as it will be understood in this whole memoir, the temperature of the *variable body*, these transformations are excluded from N. Furthermore a remark

8. If the process have taken place in such a manner that it may be executed inversely in the same way, $N=0$. If however there occur in the circular process one or more changes of condition which have taken place in a manner which cannot be inverted, then uncompensated transformations have come into play, and the magnitude N has an assignable value, which however can only be positive.

Among the processes to which this last finds an application, one in particular will in future be frequently discussed. When a quantity of gas or vapor expands, and in so doing overcomes a pressure corresponding to its whole expansive force, it may be again compressed by an application of the same force, in which case all the phenomena with which the expansion was accompanied occur in an inverse manner. This is however no longer the case when the gas (or vapor) does not meet in expanding the full resistance which it could overcome, when, for instance, it streams from one vessel, in which it was under a greater pressure, into another in which a less pressure is exerted. In this case a compression is not possible under the same circumstances under which the expansion took place.

The equation (II) gives us a means of determining the sum of all the uncompensated transformations in a circular process. As however a circular process may consist of many single changes of condition of a given mass, of which some have taken place in an invertable, and others in an uninvertable manner, it is in many cases of interest to know how much each single one of the last has contributed to the production of the whole sum of uncompensated transformations. For this purpose imagine that the mass, after the change in condition which we wish in this way to investigate, is brought back by any invertable process to its original condition. In this way we obtain a small circular process to which equation (II) is as applicable as to the whole. If we know also the quantities of heat which the mass has taken up during the same, and the temperatures belonging to it, the negative integral $-\int\frac{dQ}{T}$ gives the uncompensated change which has occurred in it. Now as the restoration which has taken place in an invertable manner can have contributed nothing to

must be made on the minus sign before N, which does not occur in my previous memoir in the same equation. This difference depends only on the fact that there the positive and negative sense of the quantities of heat is chosen otherwise than here. There a quantity of heat taken up by the variable body was calculated as negative because it is lost for the source of heat, here on the other hand it is considered as positive. All the elements of heat contained in the integral hereby change their sign, and with them at the same time the whole integral, consequently in order that the equation should remain correct notwithstanding the change, it was necessary to change the sign on the other side also.

its increase, this expression represents the uncompensated transformation occasioned by the given change of condition.

If in this manner we have investigated all the parts of the whole circular process which are not invertable, and thereby determined the values N_1, N_2, &c., which must all singly be positive, their sum gives the magnitude N with reference to the whole circular process, without its being necessary to bring into the investigation those parts of which we know that they are invertable.

9. If we now apply equations (I) and (II) to the circular process which takes place in the thermo-dynamic machine during a period, we see in the first place that if the whole quantity of heat which the mediating substance has taken up during this time is given, then the work is also determined immediately by the first equation, without its being necessary to know the nature of the processes themselves of which the circular process consists. In similar generality we may, by the combination of the two equations, determine the work from other data also.

We will assume that the quantities of heat which the variable body receives one after the other, as well as the temperatures which it has at the reception of each, are given, and that there is only one temperature over and above, whose magnitude is not known *à priori*, at which a quantity of heat is still communicated to, or, if it be negative, taken from, the body. Let the sum of all the known quantities of heat be Q_1, and the unknown quantity of heat Q_0.

Then resolve the integral in equation (II) into two parts, of which one extends only over the known quantity of heat Q_1, and the other over the unknown quantity Q_0. In the last part the integration may be directly executed, since T has in it a constant value T_0, and gives the expression

$$\frac{Q_0}{T_0}.$$

The equation (II) becomes hereby

$$\int_0^{Q_1} \frac{dQ}{T} + \frac{Q_0}{T_0} = -N,$$

whence follows

$$Q_0 = -T_0 \cdot \int_0^{Q_1} \frac{dQ}{T} - T_0 \cdot N.$$

Further we have according to equation (I), as, for our case, $Q = Q_1 + Q_0$:

$$W = \frac{1}{A}(Q_1 + Q_0).$$

If we substitute in this equation for Q_0 the value just found, we have

$$(2) \qquad W=\frac{1}{A}\left(Q_1-T_0\int_0^{Q_1}\frac{dQ}{T}-T_0\,.\,N\right).$$

If we assume specially that the whole circular process is invertable, according to the above $N=0$, and the foregoing equation becomes

$$(3) \qquad W=\frac{1}{A}\left(Q_1-T_0\,.\int_0^{Q_1}\frac{dQ}{T}\right).$$

This expression is only distinguished from the previous one by the term $-\frac{T_0}{A}\,.\,N$. Since N can only be positive this term can only be negative, and we see from this, which is also easily deduced from a direct consideration, that we obtain the greatest possible amount of work under the conditions above determined, when the whole circular process is invertable, and that the quantity of work is diminished by every circumstance which causes one of the special processes occurring in the circular process to be uninvertable.

Equation (2) leads accordingly to the sought value of the work in a manner which is directly opposed to the usual one, inasmuch as we do not, as formerly, determine singly the quantities of work performed during the different processes and then add them together, but set out from the maximum work, and subtract from it the losses of heat which have arisen from the single incomplete parts of the process.

If we make the limiting condition with respect to the communication of the heat that the whole quantity of heat Q_1 is communicated to the body at a determined temperature T_1, the portion of the integration embracing this quantity of heat may be at once executed, and gives

$$\frac{Q_1}{T_1},$$

by which equation (3), which holds good for the maximum of the work, takes the following form,

$$(4) \qquad W=\frac{Q_1}{A}\,.\,\frac{T_1-T_0}{T_1}\,.$$

In this special form the equation was already deduced by W. Thomson and Rankine from the combination of Carnot's theorem, modified by me, with the theorem of the equivalence of heat and work.*

10. Before we can pass from these considerations, which hold good for all thermo-dynamic machines, to the treatment of the steam engine, some remarks with respect to the behavior of vapors at a maximum density must first be brought forward.

* Phil. Mag., July, 1851.

I have already in my former paper of 1850, on the motive power of heat, developed the equations which represent the two principal theorems of the mechanical theory of heat in their applications to vapors at a maximum density, and have applied them to deduce various conclusions.

As I have however introduced in my last memoir "on a change in the form of the second principal theorem of the mechanical theory of heat," a somewhat different mode of representing the whole subject, I consider it, as already mentioned, more advantageous for the sake of greater simplicity and breadth of view, to suppose only this last memoir as known. I will therefore again deduce in a different way the equations referred to from the results obtained in it.

In this memoir it was assumed, in order to apply the general equations first established to a somewhat more special case, that the only foreign force acting upon the variable body which deserves consideration in determining the external work, was an external pressure, the force of which was equal at all points of the surface, and whose direction was every where perpendicular to it, and that further this pressure always changed only so slowly, and consequently was at every instant only so little different from the expansive force of the body acting opposite to it, that in calculation the two might be considered as equal. If then we denote by p the pressure, by v the volume, and by T the absolute temperature of the body, which last we will introduce into the formulas instead of the temperature as estimated from the freezing point, because they take a simpler form in this way, the equations deduced for this case are as follows,

$$\text{(III)} \qquad \frac{d}{dT}\left(\frac{dQ}{dv}\right) - \frac{d}{dv}\left(\frac{dQ}{dT}\right) = A \cdot \frac{dp}{dT}$$

$$\text{(IV)} \qquad \frac{dQ}{dv} = A \cdot T \frac{dp}{dT}.$$

These equations are now to be applied to the still more special case of vapors at a maximum density.

11. Let the given mass of the substance whose vapor is to be considered be M, and let this be contained in a completely closed extensible vessel, the part m in a state of vapor, and the remaining part, $M-m$, in a fluid state. This mixed mass is now to form the variable body to which the previous equations are to be applied.

If the temperature T of the mass and its volume v—that is to say, the content of the vessel—are given, then the condition of the mass, so far as it here comes under consideration, is thereby completely determined. Since namely, the vapor by supposition always remains in contact with the liquid, and consequently at a maximum density, its condition, as well as that of the liquid,

depends only on the temperature T. It only remains to decide whether the quantity of the two parts which are present in different conditions is determined. For this purpose the condition is given, that these two parts must together exactly fill up the content of the vessel. If we therefore denote the volume of the unit of weight of steam, at its maximum density, at the temperature T by s, and that of a unit of weight of fluid by σ, we must have:

$$v = m \,.\, s + (M - m)\sigma$$
$$= m(s - \sigma) + M\sigma.$$

The quantity s occurs in what follows, only in the combination $(s-\sigma)$, and we will therefore introduce a special letter for this difference, putting

$$(5) \qquad u = s - \sigma,$$

by which the previous equation becomes

$$(6) \qquad v = mu + M\sigma,$$

and hence

$$(7) \qquad m = \frac{v - M\sigma}{u}.$$

By this equation, m is determined as a function of T and v, since u and σ are functions of T.

12. In order now to be able to apply equations (III) and (IV) to our case, we must first determine the quantities $\frac{dQ}{dv}$ and $\frac{dQ}{dT}$.

Let us first assume that the vessel expands so much that its content increases by dv, then a quantity of heat must be thereby communicated to the mass, which will in general, be represented by

$$\frac{dQ}{dv}\,dv.$$

Now since this quantity of heat is only consumed in the formation of vapor which takes place during the expansion, it may also be represented, if the heat of evaporation be denoted for the unit of mass by r, by the expression

$$r\frac{dm}{dv}\,dv,$$

and we may also put

$$\frac{dQ}{dv} = r\frac{dm}{dv}$$

whence, since according to (7),

$$\frac{dm}{dv} = \frac{1}{u},$$

we find

$$(8) \qquad \frac{dQ}{dv} = \frac{r}{u}.$$

If we assume in the second place, that the temperature of the mass, while the content of the vessel remains constant, is in-

creased by dT, the quantity of heat necessary, will be represented generally by

$$\frac{dQ}{dT}dT.$$

This quantity of heat consists of three portions—1. The fluid portion, $M-m$ of the whole mass, must be warmed by dT, for which purpose, if c denotes the specific heat of the liquid, the quantity of heat $(M-m)c\,dT$ is necessary.

2. The portion m in the state of vapor must in like manner be heated by dT, but will thereby at the same time be so much compressed, that for the increased temperature $T+dT$, it is again at a maximum density. The quantity of heat which must be communicated to a unit of mass of vapor during its compression, in order that it shall have at every density precisely the temperature for which this density is a maximum, we shall denote for an increase of temperature of dT, in general by $h\,dT$ in which h is a magnitude which is previously unknown as to its value, and even as to its sign. The quantity of heat necessary for our case, will hence be represented by $mh\,dT$.

3. In the process of heating, a small quantity of the previously fluid portion, passes into the state of vapor, which is represented generally by $\frac{dm}{dT}dT$, and which consumes the quantity of heat

$$r\frac{dm}{dT}dT.$$

In this, according to equation (7)

$$\frac{dm}{dT} = -\frac{v-M\sigma}{u^2}\cdot\frac{du}{dT} - \frac{M}{u}\cdot\frac{d\sigma}{dT}$$
$$= -\frac{m}{u}\cdot\frac{du}{dT} - \frac{M}{u}\cdot\frac{d\sigma}{dT},$$

by which the previous expression becomes

$$-r\left(\frac{m}{u}\cdot\frac{du}{dT}+\frac{M}{u}\cdot\frac{d\sigma}{dT}\right)dT.$$

If we add these three quantities of heat together, and put their sum equal to $\frac{dQ}{dT}dT$ we have

$$(9)\qquad \frac{dQ}{dT} = M\left(c-\frac{r}{u}\cdot\frac{d\sigma}{dT}\right)+m\left(h-c-\frac{r}{u}\cdot\frac{du}{dT}\right).$$

13. The first of these expressions for $\frac{dQ}{dv}$ and $\frac{dQ}{dT}$, must now also, as is signified in equation (III), be differentiated, the first with respect to T, and the last with respect to v. If we consider moreover that the quantity M is constant, the quantities u, σ, τ,

c and h, only functions of T, and the quantity m only a function of T and v we obtain

$$\frac{d}{dT}\left(\frac{dQ}{dv}\right)=\frac{1}{u}\cdot\frac{dr}{dT}-\frac{r}{u^2}\cdot\frac{du}{dT} \tag{10}$$

$$\frac{d}{dv}\left(\frac{dQ}{dT}\right)=\left(h-c-\frac{r}{u}\cdot\frac{du}{dT}\right)\frac{dm}{dv}.$$

or, if we put for $\frac{dm}{dv}$ its value $\frac{1}{u}$,

$$\frac{d}{dv}\left(\frac{dQ}{dT}\right)=\frac{h-c}{u}-\frac{r}{u_2}\cdot\frac{du}{dT}. \tag{11}$$

By substituting the expressions given in (10), (11), and (8), in (III) and (IV) we obtain the sought equations, which represent the two principal theorems of the mechanical theory of heat for vapors at a maximum density, namely

$$\frac{dr}{dT}+c-h=A\,.\,u\,.\,\frac{dp}{dT}. \tag{v.}$$

$$r=A\,.\,Tu\frac{dp}{dT}. \tag{VI.}$$

and from the combination of the two, we also obtain

$$\frac{dr}{dT}+c-h=\frac{r}{T}. \tag{12}$$

14. With the help of these equations we will now consider a case which will so often occur in what follows, that it is advantageous to fix, à priori, the results which refer to it.

Let it namely be assumed that the previously considered vessel with its contents of partly fluid and partly vaporized mass, changes its volume, without any heat being added to or taken from the mass. Then together with the volume, the temperature and the quantity of that portion of the mass which is present in the form of vapor will change, and besides, a positive or negative external work will be done by the heat which produces the pressure of the vapor, since in the change of volume the pressure of the enclosed vapor which is exerted in the expansion overcomes an external force, and in the compression is overcome by an external force.

Under these circumstances, the quantity of the portion m, in the form of vapor, the volume v and the work W are to be determined as functions of the temperature T.

15. If the volume and the temperature are changed by the arbitrary infinitely small quantities dv and dT, the quantity of heat, which for this purpose must be communicated to the mass, will be expressed according to the foregoing by the sum

$$r\frac{dm}{dv}\,dv+\left[(M-m)c+mh+r\frac{dm}{dT}\right]dT.$$

This sum must be equated to zero, in consequence of the condition now laid down that heat must neither be communicated to nor taken from the mass. In this way we obtain, if we simply write dm for

$$\frac{dm}{dv}dv+\frac{dm}{dT}dT,$$

the equation

$$(13) \qquad r\,dm+m(h-c)\,dT+Mc\,dT=0.$$

If we substitute in this, according to (12)

$$h-c=\frac{dr}{dT}-\frac{r}{T},$$

and again write simply dr for $\frac{dr}{dT}dT$, since r is only a function of T, we have

$$r\,dm+m\,dr-\frac{mr}{T}\,dT+Mc\,dT=0,$$

or

$$(14) \qquad d(mr)-\frac{mr}{T}\,dT+Mc\,dT=0.$$

If we divide this equation by T, and remember that

$$\frac{d(mr)}{T}-\frac{mr}{T^2}dT=d\left(\frac{mr}{T}\right),$$

we obtain

$$(15) \qquad d\left(\frac{mr}{T}\right)+Mc\frac{dT}{T}=0.$$

As the specific heat of a liquid changes but slowly with the temperature, we will in what follows, always consider the quantity c as constant. Then the previous question may be integrated at once, and gives

$$\frac{mr}{T}+Mc\log T=\text{const.}$$

or if the initial values of T, r, m, be denoted by T_1, r_1, m_1,

$$(\text{VII}) \qquad \frac{mr}{T}=\frac{m_1r_1}{T_1}-Mc\log\frac{T}{T_1}.$$

By this equation, m is also determined as a function of the temperature, if r, as a function of the temperature, can be à priori considered as known.

In order to give an approximate view of the behavior of this function, I have collected together in the following table some values calculated for a particular case. It is assumed namely that the vessel at the beginning contains no liquid water, but is exactly filled with steam at the maximum density, so that in the previous equation m, is to be put equal to M, and let now an expansion of the vessel take place. If the vessel should be

compressed, we could not make the assumption that in the beginning no fluid water is present, because then the vapor would not remain at a maximum density, but would be overheated by the heat produced during the compression. In the expansion on the other hand, the steam remains not only at a maximum density, but a part of it is in fact condensed, and it is precisely the diminution of m produced thereby, to which the table refers. The initial temperature is assumed as 150° C., and corresponding values of $\frac{m}{M}$ are given for the times when the temperature has sunk by the expansion to 125°, 100°, etc. The temperature estimated from the freezing point is denoted by t, as heretofore, to distinguish it from the absolute temperature represented by T.

t	150°	125°	100°	75°	50°	25°
$\frac{m}{M}$	1	0·956	0·911	0·866	0·821	0·776

16. In order to express the relation between the volume v and the temperature, we have in the first place equation (6), namely $v = mu + M\sigma$. The quantity σ occurring here, which signifies the volume of a unit of weight of the liquid, changes very little with the temperature, and as besides the whole value of σ is very small with respect to u, we may with the more propriety neglect the small changes which it undergoes, and we will therefore consider σ and consequently also the product $M\sigma$ as constant. We have therefore only to determine the product mu. For this purpose we only need to substitute in the equation (VII,) for r, the expression given in (VI,) whereby we obtain

$$\text{(VIII.)} \qquad mu\frac{dp}{dT} = m_1 u_1 \left(\frac{dp}{dT}\right)_1 - \frac{Mc}{A}\log\frac{T}{T_1}.$$

The differential coefficient $\frac{dp}{dT}$ which occurs here is to be looked on as known; p itself is known as a function of the temperature, and consequently by this equation, the product mu is determined, and from it we obtain by addition of $M\sigma$ the sought quantity v.

In the following table, there is again collected a series of values of the fraction $\frac{v}{v_1}$, which are deduced from this equation, for the same case to which the foregoing table relates. For the sake of comparison, those values of $\frac{v}{v_1}$ are also added, which we should obtain if the two assumptions usually made heretofore in the theory of the steam engine were correct. (1.) that the steam

in expanding remains exactly at a maximum density, without partially precipitating, (2.) that it obeys the laws of Mariotte and Gay Lussac. According to these assumptions we should have

$$\frac{v}{v_1} = \frac{p'}{p} \cdot \frac{T}{T_1}.$$

t	150°	125°	100°	75°	50°	25°
$\frac{v}{v_1}$	1	1·88	3·90	9·23	25·7	88·7
$\frac{p'}{p} \cdot \frac{T}{T_1}$	1	1·93	4·16	10·21	29·7	107·1

17. It remains finally to determine also the work done during the change of volume. For this purpose we have generally the equation

$$(16.) \qquad W = \int_{v_1}^{v} p\,dv$$

Now according to equation (6) if σ be regarded as constant:

$$dv = d(mu)$$

whence

$$p\,dv = p\,d(mu)$$

for which we may also write

$$(17.) \qquad p\,dv = d(mup) - mu\frac{dp}{dT}dT.$$

We might put in this for $mu\frac{dp}{dT}$ the expression given by equation (VIII) and then execute the integration. We obtain the result however at once in a rather more convenient form by the following substitution. According to (VI) we have

$$mu\frac{dp}{dT}dT = \frac{1}{A} \cdot \frac{mr}{T}dT,$$

and from this by employing equation (14):

$$mu\frac{dp}{dT}dT = \frac{1}{A}\left[d(mr) + Mc\,dT\right].$$

Hence (17) becomes

$$p\,dv = d(mup) - \frac{1}{A}\left[d(mr) + Mc\,dT\right],$$

and by integrating this equation we obtain

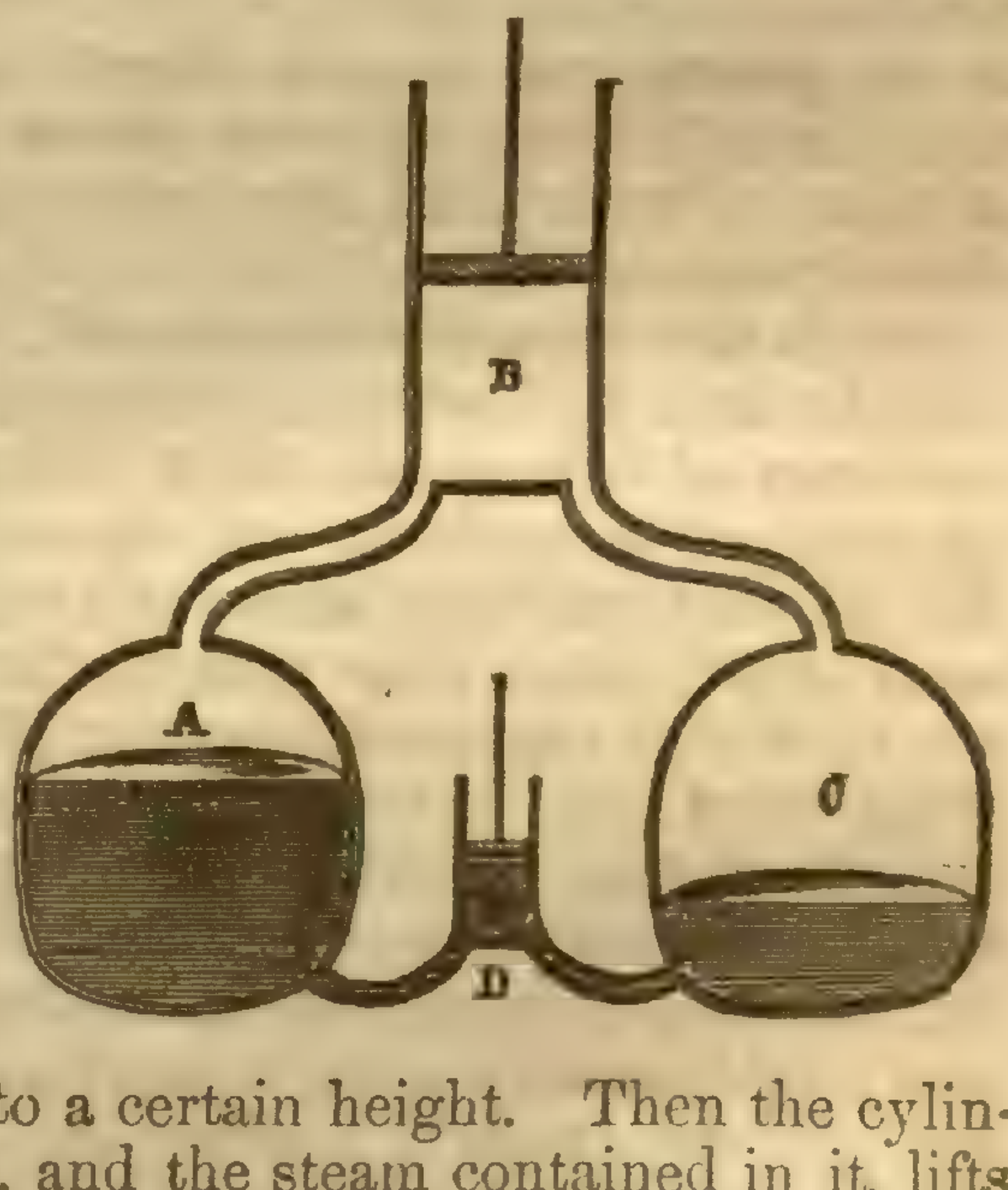
$$(IX.) \qquad W = mup - m_1u_1p_1 + \frac{1}{A}\left[m_1r_1 - mr + Mc(T_1 - T)\right]$$

whence W may be calculated, since the quantities mr and mu are already known from the foregoing equations.

I have also carried out this calculation for the above special case, whereby I have obtained the values given in the table for $\frac{W}{M}$, that is for the work done during the expansion by the unit of mass. The kilogram is selected as the unit of mass, and the kilogram-meter as the unit of work. For $\frac{1}{A}$ the value found by Joule, 423·55, is employed.* For comparison with the numbers in the table I will also add, that we obtain for the work which is done during the evaporation itself, by the steam which overcomes the external counter-pressure, in the case of which 1 kilogram of water evaporates at the temperature of 150° and under a corresponding pressure, the value 18700.

t	150°	125°	100°	75°	50°	25°
$\frac{W}{M}$	0	11300	23200	35900	49300	63700

18. We turn our attention now to the consideration of the steam engine itself. In the accompanying schematic figure, which is only intended to facilitate the general view of the whole series of processes connected with the action of a common steam-engine, let A represent the boiler, the contents of which are kept by the source of heat, at the constant temperature T_1. From this, a portion of the steam passes into the cylinder B, and forces the piston to a certain height. Then the cylinder is cut off from the boiler, and the steam contained in it, lifts the piston still higher by expansion. The cylinder is thereupon put into connexion with the space C, which shall represent the condenser. We shall assume with respect to this, that it is not kept cool by injected water but by cooling from without, which, as above remarked, produces no important difference in the results, but simplifies the consideration of the subject. Let the con-



* $\frac{1}{A}$ is the equivalent of work for the unit of heat, and the above number signifies that the quantity of heat which is able to warm 1 kilogram of water from 0° to 1°, when converted into mechanical work gives a quantity of work equal to 423·55 Kgr. M.

stant temperature of the condenser be called T_0. During the connection of the cylinder with the condenser, the piston goes back again through the whole space which it previously passed over, and thereby all the steam which did not of itself pass directly into the condenser is driven into this and is here condensed. It only remains in order to complete the cyclus of operations, to bring back into the boiler the liquid which has arisen from the condensation of the steam. This purpose is served by the small pump D, whose action is so regulated that during the ascent of the piston, it draws up exactly as much liquid from the condenser as has been brought into this last by the condensation of the steam; and this quantity of liquid is then forced into the boiler by the descent of the piston. When this has here become heated again to the temperature T_1, everything is again in the initial condition, and the same series of processes can begin anew. We have here then to deal with a complete circular process.

In common steam engines, the steam passes into the cylinder not only from one side, but alternately from both. This however produces only the difference that during an ascent and descent of the piston, two circular processes take place instead of one, and it is sufficient in this case also to determine the work for one of them in order to be able to deduce the whole work which is done during any time.

19. In this determination we will, as is customary, consider the cylinder as a shell which is impenetrable to heat, neglecting the exchange of heat which takes place during one stroke between the walls of the cylinder and the steam. The mass in the cylinder can only consist of steam at a maximum density mixed with some liquid. It is clear from the foregoing, that the steam cannot pass into the overheated condition during the expansion which takes place in the cylinder after cutting off its connection with the boiler, provided that no heat be communicated from without, but on the contrary that it must be partly precipitated, and in other processes to be mentioned farther on, which it is true might occasion a slight overheating, this is prevented by the fact that the steam in rushing into the cylinder always carries with it some liquid and remains in contact with it.

The quantity of this liquid mixed with the steam is insignificant, and as it is for the most part distributed through the steam in fine drops, and consequently can rapidly participate in the changes of temperature which the steam undergoes during the expansion, we shall make no sensible error if we consider in calculation the temperature of the whole mass in the cylinder as the same for every determined instant of time.

Furthermore, not to make the formulas too complicated at the outset, we will in the first place determine the whole work which is done by the pressure of the steam without taking into account

how much of this work is really useful, and how much on the other hand again is consumed in the machine in overcoming the friction and in moving the pumps, which are necessary for the working of the machine, beside that indicated in the figure. This part of the work may also be subsequently determined, and subtracted, as will be shown farther on.

It is moreover to be remarked with respect to the friction of the piston in the cylinder, that the work consumed in overcoming it is not to be considered as entirely lost, for by this friction heat is generated, and thereby the interior of the cylinder kept warmer than it otherwise would be, and consequently the force of the steam is increased.

Finally, as it is advantageous to learn in the first place the action of the most complete machine possible before we study the influence of the particular imperfections which naturally occur, we shall add to this preliminary consideration two suppositions which at a future time will be again given up. Namely, in the first place, that the conducting pipe from the boiler to the cylinder, and the waste-pipe from the cylinder to the condenser or to the atmosphere is so wide, or that the motion of the steam engine is so slow, that the pressure in that part of the cylinder which is in connexion with the boiler, is equal to that in the boiler itself, and in like manner, that the pressure on the other side of the piston is equal to the pressure in the condenser, or to the pressure of the atmosphere, and secondly, that no injurious space is present.

20. Under these circumstances, the quantities of work done during a circular process, may be expressed without further calculation, with the help of the results obtained above, and give a simple expression as the sum. Let the whole mass which passes during the ascent of the piston from the boiler into the cylinder, be called M, and let the part m_1 be in the form of vapor, and the part $M-m_1$ liquid. The space which this mass occupies is, if m_1 signifies the value of u belonging to T_1,

$$m_1 u_1 + M\sigma.$$

The piston is accordingly lifted as high as this space underneath it becomes free, and as this happens under the action of the pressure p_1 belonging to T_1, the work done during this first process, which we may call W_1, is

$$W_1 = m_1 u_1 p_1 + M\sigma p_1. \tag{18}$$

Let the expansion which now follows be so far continued, until the temperature of the mass enclosed in the cylinder has sunk from the value T_1 to a second given value, T_2. The work which is done hereby, which we may call W_2, is found immediately from equation (IX), if T_2 is assumed in it, as the final temperature, and also if the corresponding values are substituted for the other quantities occurring in the equation, namely :

$$(19.)\quad W_2 = m_2 u_2 p_2 - m_1 u_1 p_1 + \frac{1}{A}[m_1 r_1 - m_2 r_2 + Mc(T_1 - T_2)].$$

In the forcing down of the piston, which now begins, the mass which at the end of the expansion occupied the space

$$m_2 u_2 + M\sigma$$

is driven from the cylinder into the condenser, whereby the constant counter pressure p_0 is to be overcome. The negative work which is thereby done by this pressure is:

$$(20.)\qquad W_3 = -m_2 u_3 p_0 - M\sigma p_0.$$

While now the piston of the small pump rises so high that the space $M\sigma$ becomes free under it, the pressure p_0 which takes place in the condenser acts in its favor, and does the work

$$(21.)\qquad W_4 = M\sigma p_0.$$

Finally, at the descent of this piston, the pressure p_1 which takes place in the boiler must be overcome, and does therefore the negative work:

$$(22.)\qquad W_5 = -M\sigma p_1.$$

By the addition of these five quantities, we obtain for the whole work done during the circular process, by the pressure of the steam, or as we may also say, by the heat, which we may call W, the expression

$$(\text{x})\quad W = \frac{1}{A}[m_1 r_1 - m_2 r_2 + Mc(T_1 - T_2)] + m_2 u_2 (p_2 - p_0).$$

From this equation, the quantity m_2 must be eliminated. This quantity, if we substitute for u_2 the value deduced from (VI),

$$\frac{r_2}{A \,.\, T_2 \left(\frac{dp}{dT}\right)_2}$$

occurs only in the combination $m_2 r_2$, and for this product equation (VII) gives the expression

$$m_2 r_2 = m_1 r_1 \frac{T_2}{T_1} - Mc\, T_2 \log \frac{T_2}{T_1}.$$

By substituting this expression we obtain an equation in which only known quantities occur on the right side, since the masses m_1 and M and the temperatures T_1, T_2 and T_0 are assumed as immediately given, and the quantities r, p and $\frac{dp}{dT}$ are supposed to be known as functions of the temperature.

21. If in equation (x) we put T_2 equal to T_1, we obtain the work for the case in which the machine works without expansion, namely:

$$(23)\qquad W = m_1 u_1 (p_1 - p_0)$$

If on the other hand, we make the assumption, that the expansion is driven until the steam by the expansion has cooled from the temperature of the boiler to that of the condenser, which, it is true, it is not completely possible to do, but which still forms the limiting case to which we must approximate as closely as possible, we need only put $T_2 = T_0$ whereby we obtain

$$(24) \qquad W' = \frac{1}{A}\left[m_1 r_1 - m_0 r_0 + Mc(T_1 - T_0)\right].$$

If we also eliminate from this $m_0 r_0$ by means of the before-cited equation, in which also we must put $T_2 = T_0$, we have

$$(\text{XI}) \qquad W' = \frac{1}{A}\left[m_1 r_1 \frac{T_1 - T_0}{T_1} + Mc\left(T_1 - T_0 + T_0 \log \frac{T_0}{T_1}\right)\right]^*.$$

22. If we write the foregoing equation in the following form,

$$(25) \qquad W' = m_1 r_1 \frac{T_1 - T_0}{A T_1} + Mc(T_1 - T_0) \cdot \frac{1}{A}\left(1 + \frac{T_0}{T_1 - T_0} - \log \frac{T_0}{T_1}\right),$$

the two products which occur herein, $Mc(T_1 - T_0)$ and $m_1 r_1$, represent together the quantity of heat given out by the source of heat, during a circular process. The first is namely the quantity of heat which is necessary in order to heat the mass M which comes from the condenser in the fluid state, with the temperature T_0 up to T_1, and the last represents the quantity of heat which is required to convert the portion m_1 at the temperature T_1 into steam. As m_1 is little smaller than M, the last quantity of heat is far greater than the first.

We will bring the factor belonging to $Mc(T_1 - T_0)$ into a somewhat different form, in order to be able to compare with each other more conveniently the two factors, with which these two quantities of heat are multiplied in equation (25). If then, for the sake of abbreviation, we introduce the letter z with the signification

$$(26) \qquad z = \frac{T_1 - T_0}{T_1}$$

* The foregoing equations, which represent the work under the two simplifying suppositions mentioned at the conclusion of § 19, had been developed by me a long time since, and publicly brought forward in my lectures at the University of Berlin in the summer of 1854. When later in the year 1855 the Philos. Trans. of the Roy. Soc. of London for the year 1854 appeared, I found in them a memoir of Rankine "On the geometrical representation of the expansive action of heat and the theory of thermo-dynamic engines," and was astonished to find that Rankine had arrived at the same time, quite independently and by a different process, at equations which not only in their essential contents, but also in their form, corresponded almost completely with mine, only that Rankine had not considered the circumstance that a quantity of liquid is mixed with the steam at its entrance into the cylinder. By the earlier publication of this paper the priority was lost for this part of my investigation, nevertheless the correspondence was in so far a gratification to me, as it gave me a guarantee that the mode of considering the subject employed was really a natural one.

we have

$$\frac{T_0}{T_1 - T_0} = \frac{1-z}{z}$$

$$\frac{T_0}{T_1} = 1-z$$

and we therefore obtain

$$1 + \frac{T_0}{T_1 - T_0} \log \frac{T_0}{T_1} = 1 + \frac{1-z}{z} \log (1-z)$$

$$= 1 - \frac{1-z}{z}\left(\frac{z}{1} + \frac{z^2}{2} + \frac{z^3}{3} + \text{etc.}\right)$$

$$= \frac{z}{1.2} + \frac{z^2}{2.3} + \frac{z^3}{3.4} + \text{etc.}$$

Equation (25) or (XI) thus becomes

$$(27) \quad W' = m_1 r_1 \cdot \frac{z}{A} + Mc(T_1 - T_0)\frac{z}{A} \cdot \left(\frac{1}{1.2} + \frac{z}{2.3} + \frac{z^2}{3.4} + \text{etc.}\right)$$

The value of the infinite series enclosed in the brackets which distinguishes the factor of the quantity of heat $Mc(T_1 - T_0)$ from that of the quantity of heat $m_1 r_1$, varies, as one may easily see, between $\frac{1}{2}$ and 1 while z increases from 0 to 1.

23. We may also obtain the expression for the work very easily in another way, for this last considered case in which the steam cools by expansion to the temperature of the condenser, without following singly the different processes of which the circular process consists. In this case, namely, the circular process is invertible in all its parts—we may imagine that the evaporation takes place in the condenser at the temperature T_0, and that the mass M, of which the part m_0 is vapor, and the part $(M - m_0)$ is liquid, passes into the cylinder, and lifts the piston; that then during the descent of the piston, the steam is first compressed until its temperature has risen to T_1, and is thereupon forced into the boiler, and that finally by means of the small pump, the mass M is again forced as a liquid from the boiler into the condenser, and cools to the initial temperature T_0. The substance passes here through the same states as formerly, only in inverse order. The additions or subtractions of heat take place in a contrary direction, but in the same quantity and with the same temperature as the mass, and all the quantities of work have contrary signs but the same numerical values.

Hence it follows that in this case no uncompensated transformation occurs in the circular process. We must therefore in equation (2) put $N=0$, and thereby obtain the equation already cited in (3) in which only for the sake of correspondence, W' is to be written in place of W.

$$W' = \frac{1}{A}\left(Q_1 - T_0 \int_0^{Q_1} \frac{dQ}{T}\right).$$

Q_1 signifies herein for our case, the heat communicated in the boiler to the mass M, and we have therefore

$$Q_1 = m_1 r_1 + Mc\,(T_1 - T_0).$$

In determining the integral $\int_0^{Q_1} \frac{dQ}{T}$ the two single quantities of heat contained in Q_1, $Mc\,(T_1 - T_0)$ and $m_1 r_1$ must be particularly considered. In order to execute the integration for the first, we may write the element of heat dQ in the form $Mc\,dT$, then this portion of the integral becomes

$$Mc \int_{T_0}^{T_1} \frac{dT}{T} = Mc \log \frac{T_1}{T_0}.$$

During the communication of the last quantity of heat, the temperature is constantly equal to T_1, and the portion of the integral relating to this quantity of heat is therefore simply $\frac{m_1 r_1}{T_1}$. By substituting these values, the above expression for W' becomes the following.

$$W' = \frac{1}{A}\left[m_1 r_1 + Mc(T_1 - T_0) - T_0\left(\frac{m_1 r_1}{T_1} + Mc \log \frac{T_1}{T_0}\right)\right]$$

$$= \frac{1}{A}\left[m_1 r_1 \frac{T_1 - T_0}{T_1} + Mc\left(T_1 - T_0 + T_0 \log \frac{T_0}{T_1}\right)\right]$$

and this is the same expression as that contained in equation (XI), which we have previously found by the successive determination of the single quantities of work done during the circular process.

24. Hence it follows that *if the temperatures at which the substance conveying the action of the heat takes up the heat delivered by the source or gives out heat outwardly, are considered as previously given*, then the steam engine, under the suppositions made in deducing equation (XI) is a perfect machine, inasmuch as for a definite quantity of heat communicated to it, it does as much work as, according to the mechanical theory of heat, is possible at the same temperatures.

The matter is otherwise however if we do not regard these temperatures as given à priori, but consider them as a variable element which must be taken into consideration in judging the machine. In consequence of the fact that the liquid, during its

warming and evaporation, has much lower temperatures than the fire, and that thus the heat which is communicated to it must pass from a higher to a lower temperature, there is in N an uncompensated transformation which is not reckoned in the calculation, which with the reference to making the heat useful occasions a great loss. The work which can be obtained in the steam engine from the quantity of heat, $m_1 r_1 + Mc(T_1 - T_0) = Q_1$ is, as we see from equation (27), somewhat smaller than

$$\frac{Q_1}{A} \cdot \frac{T_1 - T_0}{T_1}.$$

If therefore the same quantity of heat could be communicated to a variable body at the temperature of the fire, which may be called T', while the temperature corresponding to the subtraction of heat, remains as formerly T_0, the work possibly to be obtained in this case according to equation (4) would be represented by

$$\frac{Q_1}{A} \cdot \frac{T' - T_0}{T'}.$$

In order to be able to compare the values of these expressions in some examples, let the temperature t_0 of the condenser be fixed at 50° C., and let the temperatures 110°, 150°, and 180° C. be assumed for the boiler, of which the first two correspond about to the low pressure engine and to the common high pressure engine, and the last is to be regarded as about the limit of the temperatures used in steam engines in practice. For these cases, the fraction depending on the temperatures has the following value.

t_1	110°	150°	180°
$\frac{T_1 - T_0}{T_1}$	0·157	0·236	0·287

Whereas the corresponding value for the temperature of t' of the fire, if we assume this only at 1000° C. is 0·746.

25. It is hereby easy to perceive what S. Carnot and after him many other authors have asserted, that in order to arrange machines moved by heat more advantageously, we must principally endeavor to make the interval of temperature $T_1 - T_0$ greater. It is thus for example in the case of the caloric air machines only then to be expected that they will obtain an important advantage over steam engines, when we succeed in making them work at considerable higher temperatures than steam engines, in which the danger of explosion forbids the application of too high temperatures. The same advantage may however also be obtained with overheated steam, since as soon as the vapor is separated from the liquid, we may heat it still fur-

ther with as little danger as if it were a permanent gas. Machines which employ the steam in this condition can unite many advantages of steam engines with those of air engines, and a practical result is therefore sooner to be expected from them, than from the air engines.

In the above-mentioned machines in which, besides water, a second more volatile substance is applied, the interval $(T_1 - T_0)$ is made larger because T_0 is made lower. The idea has also suggested itself in the same manner to increase the interval on the upper side by adding a third fluid less volatile than water. The fire would then immediately evaporate the least volatile of the three substances; this, by its condensation, the second, and this the third. According to the principle it is not to be doubted that this combination would be advantageous, how great however, the practical difficulties will be which are opposed to the execution, cannot à priori be determined.

26. Besides the imperfection of the common steam engines just mentioned, which is founded in their nature itself, these machines have many other defects, which are to be attributed more to their practical construction.

One of these has already been considered in the above developments, and is comprised in equation (x), namely, that the expansion cannot by any means be carried so far that the steam in the cylinder reaches the temperature of the condenser. If we take, for instance, the temperature of the boiler at 150°, and that of the condenser at 50°, we see from the table of § 16 that for this purpose the expansion must continue to 26 times the original volume, while in reality in consequence of many evils which occur in high expansions, we usually allow it to reach only 3 or 4, and at the utmost, 10 times the volume.

Two other defects, on the other hand, have been expressly excluded in what precedes, namely, in the first place that the pressure of the steam in one part of the cylinder is less than in the boiler, and in the other part greater than in the condenser—and secondly, the presence of the injurious space.

We must therefore now enlarge our former views, in such a manner that these imperfections shall also be taken into consideration.

(To be concluded.)

Art. XVI.—*Statistics of the Flora of the Northern United States;* by Asa Gray.

While engaged in the preparation of a second edition of the *Manual of the Botany of the Northern United States*, I was requested by an esteemed correspondent, upon whose judgment I place great reliance, to exhibit, in a compendious and convenient form, the elements of the flora I was occupied with. I accede to this request only because I may be presumed to possess considerable facilities for collecting and correcting a portion of the required data. But I cannot command the time needed for a proper elaboration and discussion of these materials, nor have I any special aptitude for this kind of research. I may, however, collect and arrange the principal data; for the use of those better qualified to discuss them, and to indicate their bearings upon many questions of the highest scientific interest, respecting the geographical distribution, the mutual relations, the nature, and the origin of the existing species of plants;—questions some of them so speculative or so difficult that they are not likely to be conclusively answered in our day; others more nearly within our reach; but all perhaps capable of some elucidation from the critical comparison of the flora of any one considerable region with the vegetation of other parts of the world.

The work,* which forms the basis of the following statistics of the botany of the Northern United States, has now been extended in geographical area beyond the limits of the Northern States, politically so called; inasmuch as this area includes Virginia and Kentucky, and stretches westward to the Mississippi River. The southern boundary of 36° 30′ has been adopted (instead of Mason and Dixon's line) because it coincides better than any other direct geographical line with the natural division between the cooler-temperate and the warm-temperate vegetation,—between the flora of the northern and of the southern Atlantic states. Few characteristically southern plants advance to the north of it, and those chiefly on the coast of the low southeastern corner of Virginia, in the Dismal Swamp, and the environs of Norfolk. Could we vary the line where it intersects the longitude of Washington, carrying it north until it reaches James River, and thence due east again, the small quadrangle thus excluded would exclude nearly all the properly southern indige-

* Manual of the Botany of the Northern United States; second edition; including Virginia, Kentucky, and all east of the Mississippi: arranged according to the Natural System; by ASA GRAY, (the Mosses and Liverworts by Wm. S. Sullivant). With 14 plates, illustrating the Genera of the Cryptogamia. New York: George P. Putnam & Co., 1856.

nous plants now comprised in the volume,* and mark the true division eastward between our southern and our northern botanical regions, namely, at the northern limit of the Live Oak, the Long-leaved Pine, and the Black Moss (*Tillandsia usneoides*), which grows pendent from their boughs.

On the Mississippi, the plant most southern in character which crosses the parallel is *Jussiæa repens*. This sparingly extends up the Ohio to lat. 38°, where also the *Taxodium* reaches about as far north as on the Atlantic coast.

In the elevated region through which the middle of our southern boundary passes, great numbers of northern plants are of course found to extend much farther southward.

Our western boundary, the Mississippi River, while it takes in a considerable prairie-region, excludes nearly all the plants peculiar to the wide western woodless plains, which stretch from the Saskatchewan to Texas and New Mexico, and approach our borders in Minnesota and Iowa. A list of the plants which we may be said to have derived from this region will be given hereafter.

The northern boundary, being that between the United States and British America, varies through about five degrees of latitude, and nearly embraces Canada proper on the east and on the

* It would apparently exclude from the flora of the Northern States the following species:—

Gordonia Lasianthus.
Stuartia Virginica.
Zanthoxylum Carolinianum.
Berchemia volubilis.
Viburnum obovatum.
Mitreola petiolata.
Liatris odoratissima.
" paniculata.
Sericocarpus tortifolius.
Chrysopsis gossypina.
Baccharis glomeruliflora.
Kalmia hirsuta.
Ilex Cassine.
" myrtifolia.
" Dahoon.
Gelsemium sempervirens.
Forsteronia difformis.
Olea Americana.
Fraxinus platycarpa.
Benzoin melissæfolium.
Tetranthera geniculata.
Stillingia sylvatica.
Quercus virens.
" cinerea.
Sagittaria falcata.
Burmannia biflora.
Tillandsia usneoides.
Smilax Walteri.
" lanceolata.
Zygadenus glaberrimus.
Mayaca Michauxii.
Pæpalanthus flavidus.
Lachnocaulon Michauxii.
Vilfa Virginica.
Ctenium Americanum.
Uniola paniculata.
Paspalum distichum.
" Digitaria.

Probably a good many more southern species inhabit this corner of Virginia, of which I have as yet no indications. There is little doubt that the long-leaved Pine crosses the line, and perhaps an arborescent *Yucca* grows on the sea-shore.—Of characteristically southern trees that have found their way still farther northward on the coast, even beyond Virginia, I can only mentiun two, namely, the Red Bay (*Persea Carolinensis*) and the Bald Cypress (*Taxodium distichum*), both found in Delaware, a little beyond lat. 38° 30′. Two other characteristic trees, viz., the Palmetto and *Magnolia grandiflora*, stop about as far short of our line as the two former pass beyond it.

west; so that the volume in question probably contains nearly all the plants of Canada East, south of the St. Lawrence and of lat. 47°, and of Canada West, south of lat. 46°, or perhaps 45°. Our northern boundary rises highest at its western extremity, even to lat. 49°. But the botany of the district beyond Fond du Lac, lat. 47°, is little known. Probably many plants of the northwestern plains are to be found there, which are otherwise strangers to our region, as well as all or most of the species known to occur on the northern but not on the southern shore of Lake Superior.*

A list of the additional Canadian species, as far as now known, is appended.†

The simplicity of our flora, as a purely northern temperate one, is preserved by the absence throughout our limits of high mountains and of any considerable extent of elevated land, es-

* The following Phænogamous plants, contained in Prof. Agassiz's published list of the plants gathered on the north shore of Lake Superior, in his expedition made in 1848, are not included in the Botany of the Northern States, viz :

Ribes oxyacanthoides.
Lonicera involucrata.
Corispermum hyssopifolium.
Tofieldia calyculata vel palustris.
Carex Vahlii.

To which I may add, that obscure and ambiguous Grass, the *Aira melicoides*, Michx., (Graphephorum, *Beauv.*). The last two, viz., *Tofieldia palustris* and *Carex Vahlii*, with an interesting Fern, *Allosorus acrostichoides*, are in Prof. Whitney's list (in Messrs. Foster and Whitney's Report on the Geology of the Lake Superior Land District, 1851), and having been gathered on Isle Royale, strictly claim admission into our Flora. But I was not aware in time that Isle Royale fell within the limits of the United States; and, seeing that in any case it geographically and botanically pertains to the northern shore, where the vegetation begins to display a subalpine character, which it does not upon the south side, I determined to take the southern shore of the lake for our boundary.

† This list includes the few just enumerated as found on the immediate coast of Lake Superior, although only one of the seven, viz., Ribes oxyacanthoides, is truly Canadian. Three of them come from the northwest and west, and three from the Hudson's Bay country. I exclude the introduced species, reckoning among these *Hesperis matronalis*, *Sisymbryum Sophia*, &c.: also all those mentioned as Canadian by Pursh, which have not been confirmed by later observers.

Aquilegia vulgaris (A. brevistyla, *Hook.*).
Turritis patula.
" retrofractra.
Thlaspi alpestre (?)
Linum perenne.
Oxytropis Lamberti (?)—the plant of Quebec, so-called.
Ribes oxyacanthoides.
Lonicera involucrata.
Hieracium vulgatum.
Nardosmia frigida.
Matricaria inodora.
Aster Cornuti.
Gentiana acuta.
Polemonium cæruleum.
Corispermum hyssopifolium.
Elæagnus argentea.
Tofieldia palustris.
Goodyera (Spiranthes, *Hook.*) decipiens.
Carex Vahlii.
Graphephorum melicoides. (Poæ sp.?)
Elymus Europæus, *ex Hook.*
Allosorus acrostichoides.

So far as we know at present, therefore, only 22 indigenous Phænogamous species and Ferns (of which 12 are also European) would therefore be added, by comprising Canada proper, that is, the country bordering the north of the St. Lawrence and of the Great Lakes.

pecially at the north, and the consequent paucity of truly alpine or even subalpine species. We have an alpine region indeed; but it is restricted to a few isolated mountain-tops in the northern part of New England and New York, between or near lat. 44° and 45°. The White Mountains of New Hampshire furnish far the larger part, viz., the range strictly so called, with six or seven square miles (taken horizontally) of alpine region, of which the highest point slightly exceeds 6200 feet in elevation, and its lower limit is about 4500 feet above the level of the sea, and Mount Lafayette (reaching to 5200 feet) along with other smaller patches, together making up almost as much more. Mount Katahdin in Maine (about 5300 feet high) may furnish a square mile or so of alpine region. The Green Mountains of Vermont (with a maximum elevation of 4360 feet) present mere vestiges of alpine vegetation in one or two places; and two or three summits of the Adirondack Mountains of northeastern New York (with a maximum elevation said to exceed 5400) are of a more decidedly alpine character, but apparently of small extent and far from rich in species.

The southern shore of Lake Superior affords no alpine and perhaps no strictly subalpine species; nor do any occur in the Alleghany Mountains, although they rise to above 5000 feet at one point in the south of Virginia,* and to 6000 and about 6300 in North Carolina. *Scirpus cæspitosus*, *Lycopodium selago*, *Andræa petrophila*, and *Cetraria Islandica*, are the most nearly alpine species known in the Alleghany Mountains. As will be seen by the list on a following page, the number of our truly alpine species does not equal that of the southern plants which have extended into the low southeastern corner of Virginia.

After that of Europe, no northern temperate flora of equal extent, and perhaps no flora of any large region, is so well known as that of the Northern United States, at least as to its Phanerogamia and highest Cryptogamia: and although very much still remains to be done, yet we are now in condition profitably to compare our vegetation with that of Europe, and also, though less critically, with that of other parts of the northern temperate zone.

The following tables exhibit the principal elements of our flora, and some of its relations to the European, &c.

* The White Top Mountain in Virginia, just within its southern boundary, is commonly said to be about 6000 feet in elevation; but this is probably an exaggeration.

List of the Natural Orders of the Flora of the Northern United States, with the number of Genera and Species comprised in them,—distinguishing the introduced and the indigenous Species,—and of the indigenous Species common to this district and to Europe.

Class I. DICOTYLEDONÆ S. EXOGENÆ.

Orders.	Whole No. of Genera.	No. of Genera with Indigenous Species.	No. of Introduced (naturalized and adventive) Species.	Whole No. of Species.	No. of Indigenous Species.	No. of our Indigenous Species common to Europe.
Subclass. I. Angiospermæ.						
Ranunculaceæ,	21	20	6	55	49	10
Magnoliaceæ,	2	2		6	6	
Anonaceæ,	1	1		1	1	
Menispermaceæ,	3	3		3	3	
Berberidaceæ,	5	5	1	6	5	
Nelumbiaceæ,	1	1		1	1	
Cabombaceæ,	1	1		1	1	
Nymphæaceæ,	2	2		3	3	1
Sarraceniaceæ,	1	1		2	2	
Papaveraceæ,	6	2	5	7	2	
Fumariaceæ,	4	3	1	7	6	
Cruciferæ,	20	16	14	60	46	11
Capparidaceæ,	1	1		1	1	
Resedaceæ,	1		1	1		
Violaceæ,	2	2	1	19	18	1
Cistaceæ,	3	3		7	7	
Droseraceæ,	1	1		4	4	2
Parnassiaceæ,	1	1		3	3	1
Hypericaceæ,	3	3	1	19	18	
Elatinaceæ,	1	1		1	1	
Caryophyllaceæ,	19	11	17	47	30	13
Portulacaceæ,	4	3	1	5	4	
Malvaceæ,	9	7	6	15	9	
Tiliaceæ,	1	1		2	2	
Camelliaceæ,	2	2		2	2	
Linaceæ,	1	1		2	2	
Oxalidaceæ,	1	1		3	3	2
Geraniaceæ,	2	1	2	5	3	1
Balsaminaceæ,	1	1		2	2	
Limnanthaceæ,	1	1		1	1	
Rutaceæ,	2	2		3	3	
Anacardiaceæ,	1	1		6	6	
Vitaceæ,	2	2		7	7	
Rhamnaceæ,	4	4	1	7	6	
Celastraceæ,	2	2		3	3	
Sapindaceæ,	4	4	1	11	10	
Polygalaceæ,	1	1		13	13	
Leguminosæ,	36	33	14	105	91	4
Rosaceæ,	18	17	5	76	71	16

CLASS I—*continued.*

Orders.	Whole No. of Genera.	No. of Genera with Indigenous Species.	No. of Introduced (naturalized and adventive) Species	Whole No. of Species.	No. of Indigenous Species.	No of our Indigenous Species common to Europe.
Calycanthaceæ,	1	1		3	3	
Melastomaceæ,	1	1		3	3	
Lythraceæ,	4	4	1	8	7	1
Onagraceæ,	9	9		36	36	10
Loasaceæ,	1	1		1	1	
Cactaceæ,	1	1		1	1	
Grossulaceæ,	1	1		7	7	1
Passifloraceæ,	1	1		2	2	
Cucurbitaceæ,	3	3		3	3	
Crassulaceæ,	3	3	1	6	5	
Saxifragaceæ,	11	11		22	22	5
Hamamelaceæ,	3	3		3	3	
Umbelliferæ,	26	21	5	42	37	2
Araliaceæ,	1	1		6	6	
Cornaceæ,	2	2		11	11	
Caprifoliaceæ,	7	7		27	27	3
Rubiaceæ,	9	9	1	24	23	4
Valerianaceæ,	2	2	1	8	7	
Dipsaceæ,	1		1	1		
Compositæ,	83	67	27	300	273	9
Lobeliaceæ,	1	1		12	12	1
Campanulaceæ,	2	2		5	5	1
Ericaceæ,	27	27		62	62	19
Galacineæ,	1	1		1	1	
Aquifoliaceæ,	2	2		10	10	
Styracaceæ,	3	3		5	5	
Ebenaceæ,	1	1		1	1	
Sapotaceæ,	1	1		2	2	
Plantaginaceæ,	1	1	2	8	6	1
Plumbaginaceæ,	1	1		1	1	1
Primulaceæ,	11	10	1	17	16	6
Lentibulaceæ,	2	2		12	12	4
Bignoniaceæ,	4	2	2	4	2	
Orobanchaceæ,	4	4		5	5	
Scrophulariaceæ,	26	24	11	65	54	10
Acanthaceæ,	2	2		3	3	
Verbenaceæ,	4	2	3	10	7	
Labiatæ,	33	21	22	71	49	4
Borraginaceæ,	11	5	9	25	16	3
Hydrophyllaceæ,	4	4		11	11	
Polemoniaceæ,	4	4		12	12	1
Convolvulaceæ,	7	5	5	20	15	1
Solanaceæ,	6	2	6	10	4	
Gentianaceæ,	9	8	3	27	24	2
Apocynaceæ,	3	3		4	4	
Asclepiadaceæ,	5	4	1	22	21	

CLASS II—*continued.*

Orders.	Whole No. of Genera.	No. of Genera with Indigenous Species.	No. of Introduced (naturalized and adventive) Species.	Whole No of Species	No. of Indigenous Species.	No of our Indigenous Species common to Europe.
Oleaceæ,	5	4	1	10	9	
Aristolochiaceæ,	2	2		6	6	
Nyctaginaceæ,	1	1		1	1	
Phytolaccaceæ,	1	1		1	1	
Chenopodiaceæ,	9	7	11	21	10	6
Amarantaceæ,	6	5	9	14	5	
Polygonaceæ,	4	3	10	32	22	6
Lauraceæ,	4	4		5	5	
Thymeleaceæ,	1	1		1	1	
Elæagnaceæ,	1	1		1	1	
Santalaceæ,	2	2		3	3	
Loranthaceæ,	1	1		1	1	
Saururaceæ,	1	1		1	1	
Ceratophyllaceæ,	1	1		1	1	1
Callitrichaceæ,	1	1		3	3	3
Podostemaceæ,	1	1		1	1	
Euphorbiaceæ,	9	9	5	33	28	
Empetraceæ,	2	2		2	2	1
Urticaceæ,	11	10	4	19	15	1
Platanaceæ,	1	1		1	1	
Juglandaceæ,	2	2		9	9	
Cupuliferæ,	6	6		25	25	1
Myricaceæ,	2	2		3	3	1
Betulaceæ,	2	2		10	10	4
Salicaceæ,	2	2	4	28	24	3
Subcl. II. GYMNOSPERMÆ.						
Coniferæ,	8	8		20	20	2
Total,	622	522	223	1713	1490	180

CLASS II. MONOCOTYLEDONEÆ seu ENDOGENÆ.

Araceæ,	6	6		7	7	2
Typhaceæ,	2	2		7	7	6
Lemnaceæ,	1	1		5	5	4
Naiadaceæ,	5	5		16	16	12
Alismaceæ,	5	5		12	12	4
Hydrocharidaceæ,	3	3		3	3	2
Burmanniaceæ,	1	1		1	1	
Orchidaceæ,	17	17		51	51	10
Amaryllidaceæ,	4	4		4	4	
Hæmodoraceæ,	3	3		4	4	
Bromeliaceæ,	1	1		1	1	
Iridaceæ,	2	2		6	6	
Dioscoreaceæ,	1	1		1	1	
Smilaceæ,	3	3		18	18	

CLASS I—*continued.*

Orders.	Whole No. of Genera.	No. of Genera with Indigenous Species.	No of Introduced (naturalized and adventive) species.	Whole No. of Species.	No. of Indigenous Species.	No. of our Indigenous Species common to Europe.
Liliaceæ,	12	9	4	28	24	5
Melanthaceæ,	12	12		21	21	1
Juncaceæ,	3	3		26	26	14
Pontederiaceæ,	3	3		4	4	
Commelynaceæ,	2	2		6	6	
Xyridaceæ,	2	2		4	4	
Eriocaulonaceæ,	3	3		5	5	1
Cyperaceæ,	16	16	1	214	213	48
Gramineæ,	65	55	32	194	162	32
	172	159	37	638	601	141
Total Phænogamous Plants.	794	681	260	2351	2091	321

CLASS III. ACROGENÆ.

Equisetaceæ,	1	1		10	10	8
Filices,	20	20		49	49	20
Lycopodiaceæ,	2	2		12	12	6
Hydropterides (Marsileaceæ),	2	2		4	4	1
	25	25	0	75	75	35

CLASS IV. ANOPHYTA.

Musci,	80	80	0	394	394	255
Hepaticæ,	38	38	0	108	108	65
Total,	118	118	0	502	502	320
Total Cryptogamia, Cl. 3 and 4,	143	143	0	577	577	355
Total of the 4 Classes,	937	824	260	2928	2668	676

It is plain enough that the numbers in this tabular view must be essentially influenced throughout by one's views as to the limitation of species and genera. In the hands of a few botanists, the flora of the Northern States might exhibit a somewhat smaller number of species than it here does; but with most, there would undoubtedly be a stronger tendency in the opposite direction. As it is obviously impossible at present to reduce the various ideas and shades of difference that prevail respecting species to one common standard, all that can be done is to indicate the bias, or what astronomers call the *personal equation*, of each author, which must be duly considered when different

floras are to be compared. This is not the place to discuss the principles involved in the general question, nor to explain or defend any conclusions to which I may have arrived;—except to say that my determination of species in each particular case has been based on the evidence before me as irrespective of all theoretical considerations as possibly could be. It is necessary to state, however, that, so far as I can judge, the authors of the principal and most esteemed recent European Floras, if in my place, would be likely to increase the present number of our Phænogamous plants and Ferns about five per cent. One school, indeed, would doubtless add at least ten or twelve per cent. to the species here received, and give results quite incommeasurable with my own. I can only say, on my own part, that an enlarged experience certainly inclines one to take broader views of species than those which prevail among the generality of European botanists.

The numerical comparison of our Phænogamous with our Cryptogamous species, however interesting it might become in a complete flora, is here of little moment; only the higher Cryptogamia being included. Moreover, it should be noted that the *Musci* and *Hepaticæ* enumerated in the above table are those of a geographical area about twice that of the higher or Acrogenous Cryptogamia and the Phænogamia. For the distinguished American muscologist who elaborated these two orders for our 'Botany of the Northern States,' anxious to afford facilities for the study of our mosses throughout the country, has included all known to him within the whole United States east of the Mississippi, and even some as yet found only to the north and west of these limits. It is evident, also, that the number of forms admitted as species is proportionally larger in these two orders than in the rest of the work. On the other hand it is to be considered how little our mosses have as yet been collected and studied, and how likely it is, in view of their general wide range, that most of these outlying species may yet be detected within the Northern States, including Virginia and Kentucky.

We naturally restrict our attention mainly to the Phænogamous vegetation, as best known in all countries and affording the most precise data for comparison. And we exclude at once the 260 *introduced* species, most if not all of which have become denizens of our country since its settlement by Europeans, and in consequence of that settlement;—leaving the question of their origin, introduction, &c., for future consideration. Their admission into the account in the comparing our flora with that of Europe, as has been done, seriously vitiates our conclusions.*

* Thus Mr. Watson, as cited by Alph. DeCandolle (Geogr. Bot. p. 511) enumerates 602, out of 1428 phænogamous British plants, as common to Great Britain and America. I count only 321 out of 2091 phænogamous species *indigenous* to the Northern United States as indigenous also to Europe.

The numerical elements of our Phænogamous flora, considered as to classes, are, as the tabular view shows:

Dicotyledoneæ or Exogenæ,	1490 species in	522 genera.
Monocotyledoneæ or Endogenæ,	601 "	159 "
Total Phænogamous indigenous plants,	2091 "	681 "

Or about 2½ Dicotyledonous to one Monocotyledonous species.

Their distribution among the 132 Natural Orders represented in our flora (*Resedaceæ* and *Dipsaceæ* of the above table being excluded, as having no indigenous representatives), is shown in the following:

List of the principal Phænogamous Natural Orders represented in the flora of Northern United States, arranged according to the number of indigenous species they severally comprise.

	Species.		Species.
Compositæ,	273	Liliaceæ,	24
about ⅛th of the 2091 Phanerogamia.		Rubiaceæ,	23
Cyperaceæ, about $\frac{1}{10}$th, "	213	Saxifragaceæ,	22
Gramineæ, about $\frac{1}{13}$th, "	162	Polygonaceæ,	22
Leguminosæ, about $\frac{1}{24}$th, "	91	Asclepiadaceæ,	21
Rosaceæ, about $\frac{1}{29}$th, "	71	Melanthaceæ,	21
Ericaceæ,	62	Coniferæ,	20
Scrophulariaceæ,	54	Violaceæ, Hypericaceæ, and	
Orchidaceæ,	51	Smilaceæ, each	18
Ranunculaceæ,	49	Primulaceæ, Borraginaceæ,	
Labiatæ,	49	and Naidaceæ, each	16
Cruciferæ,	46	Convolvulaceæ and Urticaceæ,	
Umbelliferæ,	37	each,	15
Onagraceæ,	36	Polygalaceæ,	13
Caryophyllaceæ,	30	Lobeliaceæ, Lentibulaceæ, Pole-	
Euphorbiaceæ,	28	moniaceæ, and Alismaceæ, each,	12
Caprifoliaceæ,	27	Cornaceæ, and Hydrophyllaceæ,	
Juncaceæ,	26	each,	11
Cupuliferæ,	25	Sapindaceæ, Aquifoliaceæ, Che-	
Salicaceæ,	24	nopodiaceæ, and Betulaceæ,	
Gentianaceæ,	24	each,	10

Only 46 of our orders have 10 or more indigenous species: 63 orders have from 2 to 9 species, and 23 orders are represented each by a single species. The average allows 15·09 species to an order.

Alphonse De Candolle and others have remarked that in almost every flora of the temperate zone which is pretty thoroughly known, the eight or nine largest families comprise half of its Phænogamous plants. In the present case the first nine families, having 1026 species, lack nineteen of making half; the sum of ten families exceeds the moiety by thirty. The result is nearly the same as that brought out by De Candolle from a similar schedule, tabulated by him from Beck's Botany of the Northern

and Middle States, north of Virginia, 1833, although the elements are considerably different and the ten largest orders are not the same throughout.*

Moreover, our ten predominant families do not properly correspond with the ten mentioned by De Candolle as generally predominant in the temperate regions of the northern hemisphere: viz. "of the first rank, *Compositæ*, *Gramineæ*, *Cyperaceæ*, *Leguminosæ*; then the *Cruciferæ*, *Umbelliferæ*, and *Caryophyllaceæ*, and then, though less decidedly, the *Labiatæ*, *Rosaceæ*, and *Scrophulariaceæ*.† Nor would they do so if, by dividing the Ericaceæ into smaller orders, we were to exclude that family from the list of those (eleven in number) which severally comprise not less than two per cent of our phænogamous species. The three most predominant families accord indeed with De Candolle's conclusion, only the *Cyperaceæ* with us are remarkable for surpassing the *Gramineæ*. But the next three in our list are quite different, even if we omit *Ericaceæ*, being *Rosaceæ*, *Scrophulariaceæ*, and *Orchidaceæ*; and all three of De Candolles second rank fall below our first ten; and one of them, the order *Caryophyllaceæ* would fall still lower, if it were not reinforced by the *Illecebreæ*, so generally regarded as a distinct family.

It is easy to see that these differences are owing to the unusual richness of our flora in *Cyperaceæ* (chiefly in *Carices*), and to our poverty in *Cruciferæ*, *Umbelliferæ*, *Caryophyllaceæ*, and *Labiatæ*, especially in the second and fourth, at least as compared with corresponding parts of Europe.

* The schedule drawn from Beck's Botany is as follows:

Compositæ,	265	
Gramineæ,	169	
Cyperaceæ,	157	
Rosaceæ,	97	
Amentaceæ,	94	=1066 species out of 2125 Phænogamous plants.
Leguminosæ,	80	
Labiatæ,	59	
Ranunculaceæ,	50	
Scrophulariaceæ,	48	
Orchidaceæ,	47	

The differences are readily to be accounted for. 1. The substitution of *Amentaceæ* in this list for *Ericaceæ* in the other, results from the former Jussiæan order having been preserved entire by Beck, but distributed into several in the present work; while I have admitted the order *Ericaceæ* in its most extensive sense. 2. The precedence of *Cyperaceæ* to *Gramineæ* in my list,—which appears not to be the case in corresponding floras of the Old World,—is wholly owing to the great increase in the number of *Carices*, in which the Northern United States are absolutely very rich; which increase has resulted from the remarkable attention and repeated elaboration this genus has received since Dr. Beck's time, from several hands, and perhaps also from a minuter discrimination of the species than in other families. 3. The order *Rosaceæ*, which strangely takes precedence of the *Leguminosæ*, is unduly expanded by a crowd of nominal or traditional species, and has four times as many introduced species as the latter family. 4. The naturalized plants being included, alters the proper proportion of most of these orders, and swells the number of the Phanogamous plants to 2125, while we count only 2091 truly indigenous species within an area about one-half larger and now much more thoroughly known.

† Alph. De Candolle: Geogr. Bot., p. 1245.

I must not stop here to compare our flora with that of Europe as respects the proportions of the *predominant* families. The data on our part for such comparison are recorded above. I pass on to notice some *characteristic* features which depend upon positive differences in the families.

The orders represented in the N. European flora and not in ours are the *Resedaceæ*, *Frankeniaceæ*, *Tamariscineæ*, *Zygophyllaceæ*, *Dipsaceæ*, *Globulariaceæ*, and *Butomaceæ*;—all very small orders; five of the seven are not represented at all by indigenous species in North America; two of them are represented on our continent in what answers to the Mediterranean region.

Of our 132 orders none is peculiar to our district, and only two are restricted to the United States; namely, *Limnanthaceæ*, of one species in the Northern States and one or two in California, and *Galacineæ*, of one genus and species,—a *genus incertæ sedis*, rather than an order.

Our orders peculiar to America are the following:—

Sarraceniaceæ,	Cactaceæ,	Hydrophyllaceæ,
Limnanthaceæ,	Galacineæ,	Bromeliaceæ;
Loasaceæ,		

all of which, except *Galacineæ* and perhaps *Bromeliaceæ*, are also represented on the western side of our continent. Besides these the following 19 orders are extra-European. Those which have known representatives in western North America, that is, in Oregon and California, are repeated in the second column; those known in corresponding parts of eastern Asia, i. e. in Japan, China, and the Himalayas, in the third column.

Extra-European Orders not peculiar to America.

Extra-European Orders of the Flora of the Northern States.	Also represented in Western N. America.	Represented in Japan, China, or Himalayas.
Magnoliaceæ.		Magnoliaceæ.
Anonaceæ.		Anonaceæ.
Menispermaceæ.		Menispermaceæ.
Nelumbiaceæ.		Nelumbiaceæ.
Cabombaceæ.		Cabombaceæ.
Calycanthaceæ.		Calycanthaceæ.
Melastomaceæ.		Melastomaceæ.
Passifloraceæ.		Passifloraceæ.
Hamamelacæ.		Hamamelaceæ.
Sapotaceæ.		Sapotaceæ.
Bignoniaceæ.	Bignoniaceæ (Martynia) ?	Bignoniaceæ.
Nyctaginaceæ.	Nyctaginaceæ.	Nyctaginaceæ?
Phytolaccaceæ.	Phytolaccaceæ.	Phytolaccaceæ.
Saururaceæ.	Saururaceæ.	Saururaceæ.
Podostemaceæ.		Podostemaceæ.
Burmanniaceæ.		Burmanniaceæ.
Hæmodoraceæ.		
Commelynaceæ.		Commelynaceæ.
Xyridaceæ.		Xyridaceæ.

Thus it appears, 1, that, of our 19 extra-European orders not peculiarly American, only 3 or 4 are represented on the western or Pacific side of the United States, while all but one are represented in the corresponding parts of Eastern Asia;—indicating a curious analogy in the vegetation of the eastern sides of the two great continental masses in the northern hemisphere, which is also borne out, though not so strikingly, in a comparison of the genera.

2. That the flora of the Northern United States is remarkably rich in ordinal types, as compared with Europe, which, (exclusive of the Mediterranean region, furnished with two or three), has only seven orders that we have not, while we have 26 that are wholly unknown to the European flora.

3. And it is worth noticing that our additional or characteristic orders are all of warm-temperature or sub-tropical general character (which is the more remarkable when the lower mean temperature of the year as compared with that of Western Europe is considered): all of these 26 orders have their principal development in the tropical regions, excepting six of the smaller ones; and three of these have tropical or sub-tropical representatives.

4. But the peculiar and extra-European families do not predominate, nor overcome the general European aspect of our vegetation, on account of the fewness of their species. Of the largest in our flora (*Hydrophyllaceæ*) we count only 11 species; and the whole 26 orders give us only 64, or barely three per cent of our phænogamous species.

Our Phænogamous genera, 681 in number, average three species apiece. Far the largest genus is *Carex*, with 132 species. On the other hand one half of our genera are represented by single species; and about 92 of these are *monotypic*, having only a single known species.

The genera which are strictly confined within the geographical limits of this work are only three, namely, *Napæa*, *Sullivantia*, and *Hemianthus* (the last a dubious genus); and all three are monotypic.

The number of our genera which have no indigenous representatives in Europe appears to be 353, or twelve more than half of our whole number, (the naturalized plants being of course excluded), belonging to 95 families. In the following table (which is hastily prepared, and likely to contain not a few errors), our extra-European Phænogamous genera are enumerated, under their respective families, and their distribution in longitude is attempted to be given in the two parallel columns.

Phænogamous Genera of the Flora of the Northern United States not common to Europe, with indications of their distribution westward, and in Eastern Temperate Asia.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e., in Oregon and California.	Occurring in E. Asia, i. e., in Japan, China, or Himalayas.
Ranunculaceæ.	Trautvetteria.	Trautvetteria.	Trautvetteria.
	Zanthorhiza.		
	Hydrastis.		
	Cimicifuga.	Cimicifuga.	Cimicifuga.
Magnoliaceæ.	Magnolia.		Magnolia.
	Liriodendron.		
Anonaceæ.	Asimina.		
Menispermaceæ.	Menispermum.		
	Cocculus.		Cocculus.
	Calycocarpum.		
Berberidaceæ.	Caulophyllum.		
	Diphylleia.		
	Jeffersonia.		
	Podophyllum.		Podophyllum.
Nelumbiaceæ.	Nelumbium.		Nelumbium.
Cabombaceæ.	Brasenia.		Brasenia.
Sarraceniaceæ.	Sarracenia.		
Papaveraceæ.	Stylophorum.		Stylophorum.
	Sanguinaria.		
Fumariaceæ.	Adlumia.		
	Dicentra.	Dicentra.	Dicentra.
Cruciferæ.	Iodanthus.		
	Leavenworthia.		
Capparidaceæ.	Polanisia.		Polanisia.
Violaceæ.	Solea.		
Cistaceæ.	Hudsonia.		
	Lechea.		
Hypericaceæ.	Ascyrum.		
	Elodea.		
Caryophyllaceæ.	Anychia.		
	Mollugo.	Mollugo.	Mollugo.
Portulaccaceæ.	Sesuvium.	Sesuvium.	
	Talinum.	Talinum.	
	Claytonia.	Claytonia.	
Malvaceæ.	Callirrhöe.		
	Napæa.		
	Sida.	Sida.	Sida.
	Kosteletzkya.	Kosteletzkya.	
Camelliaceæ.	Gordonia.		Gordonia.
	Stuartia.		Stuartia.
Limnanthaceæ.	Floerkea.		
Rutaceæ.	Zanthoxylum.		Zanthoxylum.
	Ptelea.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas.
Vitaceæ.	Ampelopsis.		Ampelopsis?
Rhamnaceæ.	Berchemia.		Berchemia.
	Ceanothus.	Ceanothus.	
Sapindaceæ.	Æsculus.	Æsculus.	Æsculus.
	Negundo.	Negundo.	Negundo.
Leguminosæ.	Crotalaria.		Crotalaria.
	Dalea.	Dalea.	
	Petalostemon.	Petalostemon.	
	Amorpha.	Amorpha.	
	Robinia.		
	Wistaria.		Wistaria.
	Tephrosia.		Tephrosia.
	Æschynomene.		Æschynomene.
	Desmodium.		Desmodium.
	Lespedeza.		Lespedeza.
	Stylosanthes.		
	Apios.		
	Rhynchosia.		Rhynchosia.
	Galactia.		
	Amphicarpæa.		
	Clitoria.		Clitoria.
	Centrosema.		
	Baptisia.		
	Cladrastis.		
	Cassia.		Cassia.
	Gymnocladus.		
	Gleditschia.		Gleditschia.
	Desmanthus.	Desmanthus.	Desmanthus.
	Schrankia.		
Rosaceæ.	Gillenia.		
	Dalibarda.		
Calycanthaceæ.	Calycanthus.	Calycanthus.	
Melastomaceæ.	Rhexia.		
Lythraceæ.	Ammannia.	Ammannia.	Ammannia.
	Nesæa.		
	Cuphea.		
Onagraceæ.	Œnothera.	Œnothera.	
	Gaura.	Gaura.	
	Jussiæa.		Jussiæa.
	Proserpinaca.		
Loasaceæ.	Mentzelia.	Mentzelia.	
Cactaceæ.	Opuntia.	Opuntia.	
Cucurbitaceæ.	Sicyos.	Sicyos.	Sicyos.
	Echinocystis.		
	Melothria.		
Crassulaceæ.	Penthorum.		Penthorum.
Saxifragaceæ.	Astilbe.		Astilbe.

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas.
	Boykinia.	Boykinia.	
	Sullivantia.		
	Heuchera.	Heuchera.	
	Mitella.	Mitella.	Mitella.
	Tiarella.	Tiarella.	Tiarella.
	Itea.		
	Hydrangea.		Hydrangea.
	Philadelphus.	Philadelphus.	Philadelphus.
Hamamelaceæ.	Hamamelis.		Hamamelis.
	Fothergilla.		
	Liquidambar.		Liquidambar.
Umbelliferæ.	Crantzia.		
	Polytænia.		
	Archemora.		Archemora.
	Tiedemannia.		
	Thaspium.	Thaspium.	
	Zizia.		
	Discopleura.		
	Cryptotænia.		Cryptotænia.
	Osmorhiza.	Osmorhiza.	Osmorhiza.
	Eulophus.		
	Erigenia.		
Cornaceæ.	Nyssa.		
Caprifoliaceæ.	Symphoricarpus.	Symphoricarpus.	
	Diervilla.		Diervilla(Weigela).
	Triosteum.		
Rubiaceæ.	Spermacoce.		
	Diodia.		
	Cephalanthus.	Cephalanthus.	
	Mitchella.		Mitchella.
	Oldenlandia.		Oldenlandia.
	Mitreola.		Mitreola.
	Spigelia.		
	Polypremum.		
Compositæ.	Vernonia.		Vernonia.
	Elephantopus.		Elephantopus.
	Sclerolepis.		
	Liatris.		
	Kuhnia.		
	Mikania.		
	Conoclinium.		
	Adenocaulon.	Adenocaulon.	
	Sericocarpus.	Sericocarpus.	
	Diplopappus.	Diplopappus.	Diplopappus.
	Boltonia.		
	Brachychæta.		
	Bigelovia.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e in Japan, China, or Himalayas.
	Chrysopsis.	Chrysopsis.	
	Pluchea.		Pluchea.
	Baccharis.	Baccharis.	
	Polymnia.		
	Chrysogonum.		
	Silphium.		
	Parthenium.		
	Iva.		
	Tetragonotheca.		
	Eclipta.		Eclipta.
	Borrichia.		
	Heliopsis.		
	Echinacea.		
	Rudbeckia.	Rudbeckia.	
	Lepachys.		
	Helianthus.	Helianthus.	
	Actinomeris.		
	Coreopsis.	Coreopsis.	
	Verbesina.		
	Dysodia.		
	Hymenopappus.	Hymenopappus.	
	Helenium.	Helenium.	
	Leptopoda.		
	Baldwinia.		
	Marshallia.		
	Erechthites.		
	Cacalia.		Cacalia.
	Krigia.		
	Cynthia.		
	Nabalus.		
	Troximon.	Troximon.	
	Pyrrhopappus.		
Ericaceæ.	Gaylussacia.		
	Chiogenes.		
	Epigæa.		
	Gaultheria.	Gaultheria.	
	Leucothoë.		
	Oxydendrum.		
	Clethra.		Clethra.
	Kalmia.	Kalmia.	
	Menziesia.	Menziesia.	
	Rhodora.		
	Leiophyllum.		
	Pterospora.	Pterospora.	
	Schweinitzia.		
Galacineæ.	Galax.		
Aquifoliaceæ.	Nemopanthes.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon or California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas
Styracaceæ.	Halesia.		
	Symplocos.		Symplocos.
Sapotaceæ.	Bumelia.		
Primulaceæ.	Dodecatheon.	Dodecatheon.	
Bignoniaceæ.	Tecoma (also Catalpa.)		Tecoma (also Catalpa.)
	Bignonia.		
Orobanchaceæ.	Epiphegus.		
	Conopholis.		
	Aphyllon.	Aphyllon.	
Scrophulariaceæ.	Collinsia.	Collinsia.	
	Chelone.	Chelone.	
	Pentstemon.	Pentstemon.	
	Mimulus.	Mimulus.	
	Conobea.		
	Herpestis.	Herpestis.	Herpestis.
	Ilysanthes.		Ilysanthes.
	Hemianthus.		
	Synthyris.	Synthyris.	
	Buchnera.		Buchnera.
	Seymeria.		
	Gerardia.		
	Schwalbea.		
	Gelsemium.		Gelsemium.
Acanthaceæ.	Dianthera.		
	Dipteracanthus.		Dipteracanthus.
Verbenaceæ.	Lippia.		
	Callicarpa.		Callicarpa.
	Phryma.		Phryma.
Labiatæ.	Trichostema.	Trichostema.	
	Isanthus.		
	Cunila.		
	Pycnanthemum.	Pycnanthemum.	
	Hedeoma.		Hedeoma.
	Collinsonia.		
	Monarda.		
	Blephilia.		
	Lophanthus.	Lophanthus.	Lophanthus.
	Cedronella.		
	Synandra.		
	Physostegia.	Physostegia.	
Borraginaceæ.	Onosmodium.		
Hydrophyllaceæ.	Hydrophyllum.	Hydrophyllum.	
	Nemophila.	Nemophila.	
	Ellisia.	Ellisia.	
	Phacelia.	Phacelia.	
Polemoniaceæ.	Phlox.	Phlox.	Phlox.

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas
	Pyxidanthera.		
Convolvulaceæ.	Stylisma.		
	Dichondra.		
Gentianaceæ.	Sabbatia.		
	Frasera.	Frasera.	
	Halenia.		Halenia.
	Bartonia.		
	Obolaria.		
Apocynaceæ.	Amsonia.		Amsonia.
	Forsteronia.		
Asclepiadaceæ.	Asclepias.	Asclepias.	
	Acerates.		
	Enslenia.		
	Gonolobus.		
Oleaceæ.	Chionanthus.		
	Forrestiera.		
Nyctaginaceæ.	Oxybaphus.	Oxybaphus.	Oxybaphus.
Phytolaccaceæ.	Phytolacca.		
Chenopodiaceæ.	Cycloloma.		
Amarantaceæ.	Montelia.		
	Acnida.		
	Iresine.		
	Frœlichia.		
Lauraceæ.	Persea.		
	Sassafras.		
	Benzoin,		Benzoin.
	Tetranthera.	Tetranthera.	Tetranthera.
Thymeleaceæ.	Dirca.		
Elæganaceæ.	Shepherdia.		
Santalaceæ.	Comandra.	Comandra.	
	Hamiltonia.		
Loranthaceæ.	Phoradendron.	Phoradendron.	
Saururaceæ.	Saururus.		Saururus.
Podostemaceæ.	Podostemon.		
Euphorbiaceæ.	Cnidoscolus.		
	Acalypha.	Acalypha.	Acalypha.
	Tragia.		
	Stillingia.		Stillingia.
	Croton.	Croton.	Croton.
	Crotonopsis.		
	Phyllanthus.		Phyllanthus.
	Pachysandra.		Pachysandra.
Urticaceæ.	Laportea.		
	Pilea.		
	Bœhmeria.		Bœhmeria.
	Planera.		
Juglandaceæ.	Carya.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring W. N. America, i e in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas
Myricaceæ.	Comptonia.		
Coniferæ.	Taxodium.		
	Thuja.	Thuja.	Thuja.
Araceæ.	Arisæma.		Arisæma.
	Peltandra.		
	Symplocarpus.	Symplocarpus.	Symplocarpus.
	Orontium.		
Alismaceæ.	Echinodorus.		
Hydrocharidaceæ.	Limnobium.		
Burmanniaceæ.	Burmannia.		Burmannia.
Orchidaceæ.	Arethusa.		
	Pogonia.		
	Calopogon.		
	Tipularia.		
	Bletia.		
	Aplectrum.		
Amaryllidaceæ.	Pancratium.		
	Agave.		
	Hypoxys.		
Hæmodoraceæ.	Lachnanthes.		
	Lophiola.		
	Aletris.		
Bromeliaceæ.	Tillandsia.		
Iridaceæ.	Sisyrinchium.	Sisyrinchium.	
Smiliaceæ.	Trillium.	Trillium.	Trillium.
	Medeola.		
Liliaceæ.	Clintonia.	Clintonia.	Clintonia.
	Yucca.	Yucca.	
Melanthaceæ.	Uvularia.		Uvularia ?
	Prosartes.	Prosartes.	
	Melanthium.		
	Zygadenus.		Zygadenus.
	Stenanthium.		
	Amianthium.		
	Xerophyllum.	Xerophyllum.	
	Helonias.		
	Chamælirium.		
Pontederiaceæ.	Pontederia.		
	Heteranthera.		
	Schollera.		
Commelynaceæ.	Commelyna.		Commelyna.
	Tradescantia.		Tradescantia.
Xyridaceæ.	Mayaca.		
	Xyris.		Xyris.
Ericaulonaceæ.	Pæpalanthus.		
	Lachnocaulon.		

Table continued.

Orders.	Extra-European Genera of Eastern N. America.	Also occurring in W. N. America, i. e. in Oregon and California.	Occurring in E. Asia, i. e. in Japan, China, or Himalayas.
Cyperaceæ.	Kyllingia.		Kyllingia.
	Dulichium.		
	Hemicarpha.		
	Fuirena.		Fuirena.
	Psilocarya.		
	Dichromena.		
	Ceratoschænus.		
	Scleria.		Scleria.
Gramineæ.	Zizania.		
	Vilfa.	Vilfa.	Vilfa.
	Sporobolus.	Sporobolus.	Sporobolus.
	Muhlenbergia.	Muhlenbergia.	
	Brachyelytrum.		
	Aristida.		Aristida.
	Ctenium.		
	Bouteloua.	Bonteloua.	
	Gymnopogon.		
	Leptochloa.		Leptochloa.
	Tricuspis.		
	Diarrhena.		
	Eatonia.		
	Bryzopyrum.	Brizopyrum.	
	Uniola.		
	Arundinaria.		Arundinaria.
	Gymnostichum.		
	Amphicarpum.		
	Paspalum.		Paspalum.
	Cenchrus.	Cenchrus.	Cenchrus.
	Tripsacum.		
	Sorghum.		Sorghum.
	353	87	101

That is, 87 of our 353 extra-European phænogamous genera, or 24 per cent are common to Western North America, and 101, or 28 per cent to Eastern temperate Asia. Four per cent more of our characteristic genera are shared with an antipodal region than with the neighboring district of W. N. America. And the number is likely to increase; for we know far less of the flora of Japan and China than of California and Oregon. Drs. Hooker and Thomson's large Himalayan collections, now in the course of distribution and publication, will probably add several more to the list. Twenty-nine of these genera, or 8 per cent, are common to all three of these regions.

Our 194 genera which are neither European, N. W. American, nor E. Asiatic in temperate regions, require further discussion to show which are characteristic of Eastern North America. We will here barely notice that:

3 Belong also to Western temperate Asia, viz., *Menispermum*, *Planera*, and *Zizania*; two of these being peculiar to that district and to ours.

73 Extend southward beyond the limits of the United States and into tropical regions, or recur in the southern hemisphere.

120 Are characteristic Eastern United States genera.

As already stated, only three genera are actually restricted to the geographical area comprised in our 'Botany of the Northern United States'. If, however, we allow our area to embrace Canada, which naturally belongs to it, and also include those plants which extend southward much beyond lat. 36° 30′ only in the Alleghanies or cool upper country of the Southern States, we may enumerate 37 genera peculiar to this flora; viz.—

Zanthorhiza.	Echinocystis.	Pyxidanthera.
Hydrastis.	Sullivantia.	Dirca.
Caulophyllum.	Zizia.	Hamiltonia.
Diphylleia.	Erigenia.	Comptonia.
Jeffersonia.	Brachychæta.	Arethusa.
Adlumia.	Chiogenes.	Tipularia.
Solea.	Oxydendrum.	Aplectrum.
Hudsonia.	Rhodora.	Medeola.
Napæa.	Leiophyllum.	Helonias.
Cladrastis.	Schweinitzia.	Chamælirium.
Gymnocladus.	Galax.	Amphicarpum.
Gillenia.	Nemopanthes.	
Dalibarda.	Hemianthus.	

To show, however, how slight an influence, after all, these 37 characteristic genera exert upon our flora, we have only to remark that they comprise altogether only 39 of our species:—that is, they have only one species apiece, except *Hudsonia* and *Gillenia*, which have two each. The characteristics of our flora of the Northern States merge in those of the flora of Eastern North America, and these again into those of the North American flora generally; and no idea can be formed of the real features of a flora like ours from such a dissection, and piecemeal presentation, or from an exhibition of what is strictly peculiar to each part, rather than what is predominant,—at least as respects generic forms.

Returning now to the species,—the real exponents of vegetation;—these have already been considered as regards their numerical proportions in the several classes and orders of the flora of the Northern States: it remains to note some facts respecting their geographical distribution.

As appears from the tabular view commencing on p. 208, there are common to Europe,

180	Dicotyledonous species out of 1490,	or 12	per cent.
141	Monocotyledonous species out of 601,	or 23·4	"
321	Phænogamous Species out of 2091	or 15·3	"
35	Acrogenous Cryptogamia out of 75	or 46·6	"
320	Musci and Hepaticæ out of 502	or 63·7	"
355	Cryptogamous species out of 577	or 61·5	"

in accordance with the general fact that the lower the class the wider the geographical area occupied by the species.

In the following table I have attempted to exhibit the particular range of our indigenous phænogamous species of each natural order in longitude, through the northern temperate zone. The table has been hastily prepared, and must be often erroneous in details; but the general results are probably very near the truth.

The Indigenous Phænogamous Species of the Northern United States, viewed as to their geoyraphical distribution around the northern temperate zone.

Natural Orders.	Whole number of species in the northern United States.	East'n N. American: not extending westward beyond the Rocky Mountains.	Extending westward to the Pacific coast or near it.	Extending into Asia.	Inhabiting Asia, but not in N. W. America.	Inhabiting Asia, but not in Europe.	Extending into Europe.	Inhabiting Europe, but not in Eastern Asia.
Class I. DICOTYLEDONEÆ, seu EXOGENÆ.								
Ranunculaceæ,	49	26	20	13	1	5	10	2
Magnoliaceæ,	6	6						
Anonaceæ,	1	1						
Menispermaceæ,	3	3						
Berberidaceæ,	5	5						
Nelumbiaceæ,	1	1						
Cabombaceæ,	1			1	1	1		
Nymphæceæ,	3	1	2	1			1	
Sarraceniaceæ,	2	2						
Papaveraceæ,	2	2						
Fumariaceæ,	6	5	1					
Cruciferæ,	46	31	13	11	2		11	
Capparidaceæ,	1	1						
Violaceæ,	18	15	3	1			1	
Cistaceæ,	7	7						
Droseraceæ,	4	2	1	1			2	1
Parnassiaceæ,	3	2	1	1			1	
Hypericaceæ,	18	18						

CLASS I.—*continued.*

Natural Orders.	Whole number of species in the northern United States.	East'n N. American: not extending westward beyond the Rocky Mountains.	Extending westward to the Pacific coast or near it.	Extending into Asia.	Inhabiting Asia, but not in N. W. America.	Inhabiting Asia, but not in Europe.	Extending into Europe.	Inhabiting Europe, but not in Eastern Asia.
Elatinaceæ,	1	1						
Caryophyllaceæ,	30	14	15	12			13	1
Portulacaceæ,	4	4						
Malvaceæ,	9	9						
Tiliaceæ,	2	2						
Camelliaceæ,	2	2						
Linaceæ,	2	2						
Oxalidaceæ,	3	1	2	2			2	
Geraniaceæ,	3	1	1	1			1	
Balsaminaceæ,	2	2						
Limnanthaceæ,	1	1						
Rutaceæ,	3	3						
Anacardiaceæ,	6	5	1					
Vitaceæ,	7	7						
Rhamnaceæ,	6	6						
Celastraceæ,	3	2	1					
Sapindaceæ,	10	10						
Polygalaceæ,	13	13						
Leguminosæ,	91	84	7	4			4	
Rosaceæ,	71	43	23	17	3	2	16	1
Calycanthaceæ,	3	3						
Melastomaceæ,	3	3						
Lythraceæ,	7	5	1	1	1		1	
Onagraceæ,	36	26	10	10			10	
Loasaceæ,	1	1						
Cactaceæ,	1	1						
Grossulaceæ,	7	5	2	1			1	
Passifloraceæ,	2	2						
Cucurbitaceæ,	3	3						
Crassulaceæ,	5	5						
Saxifragaceæ,	22	15	4	4	2	2	5	3
Hamamelaceæ,	3	3						
Umbelliferæ,	37	28	9	4	3	2	2	
Araliaceæ,	6	5		1	1	1		
Cornaceæ,	11	10	1					
Caprifoliaceæ,	27	19	7	3	1		3	
Rubiaceæ,	22	18	4	3	1		4	1
Valerianaceæ,	7	6	1					
Compositæ,	273	233	29	11		2	9	
Lobeliaceæ,	12	11					1	1
Campanulaceæ,	5	3	2	1			1	
Ericaceæ,	62	35	21	18	2	1	19	2

CLASS I—*continued.*

Natural Orders.	Whole number of species in the northern United States.	East'n N. American: not extending westward beyond the Rocky Mountains.	Extending westward to the Pacific coast or near it.	Extending into Asia.	Inhabiting Asia, but not in N.W. America.	Inhabiting Asia, but not in Europe.	Extending into Europe.	Inhabiting Europe, but not in Eastern Asia.
Galacineæ,	1	1						
Aquifoliaceæ,	10	10						
Styracaceæ,	5	5						
Ebenaceæ,	1	1						
Sapotaceæ,	2	2						
Plantaginaceæ,	6	4	2	1			1	
Plumbaginaceæ,	1		1	1			1	
Primulaceæ,	16	8	8	6			6	
Lentibulaceæ,	12	8	2	4			4	
Bignoniaceæ,	2	2						
Orobanchaceæ,	5	2	3					
Scrophulariaceæ,	54	38	15	10	1		10	
Acanthaceæ,	3	3						
Verbenaceæ,	7	5	1	1	1	1		
Labiatæ,	49	42	7	4			4	
Borraginaceæ,	16	12	4	3			3	
Hydrophyllaceæ,	11	9	2					
Polemoniaceæ,	12	11	1	1			1	
Convolvulaceæ,	15	14	1	1			1	
Solanaceæ,	4	4						
Gentianaceæ,	24	22	2	2			2	
Apocynaceæ,	4	3	1					
Asclepiadaceæ,	21	21						
Oleaceæ,	9	9						
Aristolochiaceæ,	6	6						
Nyctaginaceæ,	1	1						
Phytolaccaceæ,	1	1						
Chenopodiaceæ,	10	4	5	5	1		6	6
Amarantaceæ,	5	5						
Polygonaceæ,	22	14	7	6	1		6	
Lauraceæ,	5	5						
Thymeleaceæ,	1	1						
Elæagnaceæ,	1		1					
Santalaceæ,	3	2	1					
Loranthaceæ,	1	1						
Saururaceæ,	1	1						
Ceratophyllaceæ,	1		1	1			1	
Callitrichaceæ,	3		3	3			3	
Podostemaceæ,	1	1						
Euphorbiaceæ,	28	25	3					
Empetraceæ,	2	1	1	1			1	
Urticaceæ,	15	13	2	1			1	

CLASS I—*continued.*

Natural Orders.	Whole number of species in the northern United States.	Ext'n N. American: and extending westward beyond the Rocky Mountains.	Extending westward to the Pacific coast or near it.	Extending into Asia.	Inhabiting Asia, but not in N.W.America	Inhabiting Asia, but not in Europe.	Extending into Europe.	Inhabiting Europe, but not in Eastern Asia.
Platanaceæ,	1	1						
Juglandaceæ,	9	9						
Cupuliferæ,	25	23	1	1	1		1	
Myricaceæ,	3	2	1	1			1	
Betulaceæ,	10	6	2	4	2		4	
Salicaceæ,	24	18	6	4	1		3	
Coniferæ,	20	13	7	2			2	
Class II. MONOCOTYLEDONÆ, seu ENDOGENÆ.								
Araceæ,	7	5		2	2		2	
Typhaceæ,	7	1	3	5			6	1
Lemnaceæ,	5	1		4			4	
Naiadaceæ,	16	4	4	9	5		12	3
Alismaceæ,	12	5	7	4			4	
Hydrocharidaceæ,	3	1		1	1		2	1
Burmanniaceæ,	1	1						
Orchidaceæ,	51	36	13	9	2	1	10	2
Amaryllidaceæ,	4	4						
Hæmodoraceæ,	4	4						
Bromeliaceæ,	1	1						
Iridaceæ,	6	5	1					
Dioscoreaceæ,	1	1						
Smilaceæ,	18	17	1					
Liliaceæ,	24	14	7	5	1	1	5	1
Melanthaceæ,	21	15	6	1			1	
Juncaceæ,	26	6	16	14	4		14	
Pontederiaceæ,	4	4						
Commelynaceæ,	6	6						
Xyridaceæ,	4	4						
Eriocaulonaceæ,	5	4					1	1
Cyperaceæ,	213	155	37	37	3	2	48	13
Gramineæ,	162	114	44	33	1	4	32	2
Total Monocotyledoneæ,	601	408	143	124	19	8	141	25
Dicotyledoneæ,	1490	1168	273	184	26	17	180	13
Phænogamia,	2091	1576	416	308	45	25	321	38

The data are not at hand for extending this table through the higher Cryptogamia, except for the highest class, and that imperfectly. The four orders of *Vascular* or *Acrogenous Cryptogamia* give the following results; the columns being homologous with those of the last table.

Equisetaceæ,	10	2	8	8			8	
Filices,	49	26	13	23	8	3	20	
Lycopodiaceæ,	12	4	6	7	1	2	6	1
Hydropterides,	4	2	1	1	1		1	
	75	34	28	39	10	5	35	1

These tables necessarily include the species of our small alpine region, which, being chiefly Arctic, might properly be regarded rather as intruded members of the Arctic flora. Being mostly diffused all round the world, they increase somewhat unduly the numbers of our species common to Europe and to Asia; but they are not sufficiently numerous with us to require to be formally eliminated. The following are all the Phænogamous species which, within our limits, are found *only* in our small alpine region, namely, on the summits of the White Mountains of New Hampshire, of Mount Katahdin, Maine, and the highest peaks of the Green Mountains, Vermont, and the Adirondack Mountains in Northern New York:—

Cardamine bellidifolia.
Viola palustris.
Silene acaulis.
Sibbaldia procumbens.
Dryas integrifolia, (fide Pursh).
Potentilla frigida.
Epilobium alpinum, var. majus.
Saxifraga rivularis.
Gnaphalium supinum.
Nabalus Boottii.
Nabalus nanus.
Vaccinium cæspitosum.
Arctostaphylos alpina.
Phyllodoce taxifolia.
Rhododendron Lapponicum.
Veronica alpina.
Diapensia Lapponica.
Oxyria reniformis.
Betula nana.
Salix phylicifolia.
Salix Uva-Ursi.
Salix repens.
Salix herbacea.
Luzula arcuata.
Luzula spicata.
Juncus trifidus.
Carex capitata.
Carex atrata.
Phleum alpinum.
Calamagrostis Pickeringii.
Poa laxa.
Aira atropurpurea.
Hierochloa alpina.

Of these 33 species, two (*Nabalus Boottii* and *Calamagrostis Pickeringii*) are peculiar to our own alpine region, so far as is now known, but they are most likely to occur further north; and two (*Nabalus nanus* and *Vaccinium cæspitosum*) are peculiarly North American. All the rest are European, and with two or three exceptions also Asiatic. No one of our vascular Cryptogamous species is wholly alpine, *Lycopodium Selago* comes the nearest to being so.

The following are with us subalpine species; they occur in our alpine region (to which most of them properly belong), but also out of it, at least in one or two places.

Alsine Grœnlandica.
Geum radiatum.
Arnica mollis.
Vaccinium uliginosum.
Euphrasia officinalis.
Polygonum viviparum.
Empetrum nigrum.
Platanthera obtusata.
Scirpus cæspitosus.
Carex scirpoidea.
Carex capillaris.
Trisetum subspicatum.

All of these except *Geum radiatum*, *Arnica mollis*, and *Carex scirpoidea*, are also European. The last grows in Greenland.

The following European species have not been detected in any properly alpine habitat with us (where they might be expected to occur), but elsewhere, three of them (*Saxifraga aizoides* and *Carex gynocrates*) in stations not even subalpine:

Saxifraga oppositifolia.
Saxifraga aizoides.
Saxifraga Aizoon.
Artemisia borealis.
Juncus Stygius.
Carex gynocrates.

Two Ferns might be added to the subalpine list, viz:—*Woodsia glabella* and *Aspidium fragrans*.

The Phænogamous species whose range, so far as is now known, falls wholly within the limits of the 'Manual of the Botany of the Northern United States' are the following:

Dicotyledonous.	Monocotyledonous.
Dentaria maxima.	Lemna perpusilla.
Vesicaria Shortii.	Potamogeton Robbinsii.
Napæa dioica.	" Tuckermani.
Sida Napæa.	Trillium nivale.
Psoralea stipulata.	Veratrum Woodii.
Astragalus Robbinsii?	Helonias bullata.
Ludwigia polycarpa.	Narthecium Americanum.
Tillæa simplex.	Juncus Greenii.
Sullivantia Ohionis.	Cyperus Grayii.
Galium concinnum.	Eleocharis rostellata.
Fedia Fagopyrum.	" compressa.
" umbilicata.	" Robbinsii.
" patellaria.	Psilocarya scirpoides.
Eupatorium pubescens.	Rhynchospora capillacea.
" resinosum.	Carex exilis.
Solidago Ohioënsis.	" Sartwellii.
" Houghtonii.	" sychnocephala.
" neglecta.	" Crawei?
" Muhlenbergii.	" formosa.
" linoides.	" Careyana.
" Shortii.	" retrocurva.
" rupestris.	" Sullivantii.

Dicotyledonous.	Monocotyledonous.
Rudbeckia speciosa.	Carex mirata.
Coreopsis bidentoides.	" Grayii.
Cirsium pumilum.	Sporobolus compressus.
Nabalus Boottii.	" serotinus.
Gaylussacia brachycera.	Calamagrostis confinis.
Utricularia clandestina.	" Pickeringii.
" resupinata.	" brevipilis.
Hemianthus micranthemoides.	Dupontia Cooleyi.
Pycnanthemum clinopodioides.	Glyceria acutiflora.
" Torreyi.	Poa alsodes.
Asclepias Sullivantii.	" debilis.
" Meadii.	Amphicarpum Purshii.
Blitum maritimum.	
Polygonum Careyi.	
Ulmus racemosa.	
37 species.	34 species = 71.

(*To be continued.*)

Art. XVII.—*Letter on the Museum of Practical Geology of Great Britain;* by Sir Roderick I. Murchison.*

TO THE RIGHT HON. LORD STANLEY OF ALDERLY, &c. &c.

Having heard that Her Majesty's Government proposes to remove the Department of Science and Art, at present under the control of the Board of Trade, to the office of the Minister of the Crown who may be charged with the education of the people, I beg to be permitted to place on record a few observations on the effect which such a change may produce upon the establishment in Jermyn-Street, as consisting of the Geological Survey of the United Kingdom and its affiliated School of Mines and illustrative Museum.

Impressed with the great value of the scheme of bringing science and art to bear upon the productive industry of the country, and anxiously desirous, as well as every professor in this establishment, to aid zealously in so good a cause, I have to request that the following statement may be considered as an exposition of the views entertained by my associates and myself.

I will first recall to your Lordship's notice, briefly, the origin of this establishment and the objects which it was destined to accomplish by the additions which were made to it; and having shown that all other states, seeking to develop their mineral

* From a "Copy of Correspondence between the Director-General of the Geological Survey and the President of the Board of Trade and the Council of Education, relative to annexing a Museum of Practical Geology to the Department of Arts and Sciences."

wealth, have analogous institutions, attention will be drawn to the following points.

First. What real benefits will be derived from our establishment, if it be duly encouraged as a higher School of Mines?

Second. What may result, if it be rendered subordinate to the system of the general education of the country?

It is wholly unnecessary to comment upon the desirableness of a complete geological survey of the British Isles, as first established at the suggestion of my lamented predecessor, Sir Henry De la Beche, which has now been successfully in action for nearly twenty years, and which, whilst it affords the most important information respecting the composition of the sub-soil, has been considered by all persons eminent in geological and mining science, to have been conducted with surpassing skill.

This survey, which is the base of the whole establishment, has its analogue in most civilized lands, and the country void of it must remain ignorant of that knowledge of the crust of the earth which is indispensable in every effort to promote the material interest of man. Acting on this principle, each government of the Great American Republic has its state geologist, just as the continental governments of Europe have colleges and schools specially adapted to the instruction of miners, the chief and active officers of which construct the geological maps of their respective regions.

The object, therefore, of my predecessor was to induce the British government and Parliament to emulate other countries, by adding to the survey an illustrative Museum and a School of Mines; so that England, which, through the spirit and enterprise of individuals, had already taken a prominent lead in geological science, and had seen her own insular names rendered classical throughout the scientific world, might also possess a central school for sound instruction, not only in geology, mining, and mineralogy, but also in the essentially connected sciences of natural history, chemistry, metallurgy, mechanics and physics.

The effects which have resulted from our teaching have been beneficially felt both at home and through the most distant regions, inasmuch as our school has already afforded geological and mining surveyors to many of our colonies in the East Indies, Australia, and the Cape; whilst at this moment the legislature and governments of the West Indies are petitioning for mineral surveyors of their respective islands, and Her Majesty's government joining, as I am happy to say, in this enlightened and liberal movement, have applied to me to recommend suitable persons for such employments.

In relation to Britain, I may be permitted here to suggest, that the encouragement which is now offered to our School of Mines might at once receive considerable stimulus by a declaration on

the part of Her Majesty's government, that no one of the twelve inspectors of coal mines, each receiving a salary of 400*l.* per annum, should be appointed, who had not undergone the preliminary studies which our institution affords. If such and other encouragements were held out abroad as well as at home, and if every person appointed by the crown to all such offices should first either obtain good certificates after studying in our school, or at all events pass a satisfactory examination at it, the number of our pupils would doubtless augment rapidly. Just as scholarships, fellowships, livings and all the higher offices of state and law, are the real attractions which have hitherto filled the ancient universities, so would the public then see that a beneficial career was open to youths through the study of the sciences which we teach.

A really encouraging move, one which has produced the best effects upon our students, has indeed been made in this direction through the enlightened views of His Royal Highness Prince Albert, who, acting for His Royal Highness the Prince of Wales, as Duke of Cornwall, presented to our establishment two scholarships of the annual value of 30*l.* each.

Even in our present condition, nearly 100 officers of Her Majesty's or the Honorable East India Company's services have spontaneously taken advantage of our scientific instruction, which they know will give them advantages in foreign lands; instruction too, which they obtain with us, at half the usual charges, and which cannot be had elsewhere in this country.

Nor let it be supposed that, in any case where a young man is really desirous to gain knowledge, he is not adequately taught; inasmuch as every one of our professors acts both as teacher and examiner, and takes upon himself the tutorial responsibility of ascertaining that he has truly imbued his pupil with sound knowledge.

A striking proof of the interest attached to the useful instruction afforded by our institution is also given by the presence of 600 working men who attend the courses of evening lectures delivered gratuitously by our professors; the tickets being so sought after, that they are applied for and distributed within five hours from the commencement of their issue.

That the publication of the "Memoirs of the Geological Survey" have an important influence, is evident from the fact that, whenever they refer to districts charged with mineral wealth, their publication is speedily exhausted and new editions called for. In alluding to the utility of these publications I beg specially to call attention to a volume about to be issued by our Metallurgical Professor, Dr. Percy, viz., the "Analyses of British Iron Ores." As these results have been obtained in our laboratory and involved in their investigation the elaborate analyses of

all the British iron ores of commercial value, in number amounting to more than 100 varieties, and occupying the time of two chemists incessantly during a period of nearly three years, they prove the extent to which we have been preparing to meet the rivalry of foreign countries, by that close scientific research, the spreading results of which among our industrial population can alone enable us to maintain our present position as the chief manufacturing country in the world.*

Putting aside the consideration of these branches of our studies, the successful cultivation of which is not so obvious to the mass of mankind, but without which no scientific education can be complete, I now pass from the working of our establishment in its present relations to the government, to notice certain impediments to our success as a national scientific establishment, which may arise, if our body should, by a change of relations, be governed by the same influences as those which are likely to prevail in the general management of the education of the people.

Liberal as the minister may be under whose control the general education of the nation may be placed, there is little doubt that in this country the greater number of its instructors will be drawn from among such of the graduates of the ancient universities, as, both by their training and position must be, to a great extent, disqualified from assigning their due importance to the practical branches of science. Such persons may be eminent in scholarship and abstract science, and yet ignorant of the fact that the continued prosperity of their country absolutely depends upon the diffusion of scientific knowledge among its masses. They may, with the most sincere and earnest intention, not only fail to advance, but even exercise a retarding influence on such diffusion, and may object to a course of study which, as now pursued, is irrespective of religious teaching. Experience has shown in how sickly a manner practical science is allowed to raise its head under the direction of those persons whose pursuits are alien to it; whilst in every land, where it has had due support, the greatest benefits have resulted.

Placed as the geological survey and its affiliated branches now are, in subordination to the Board of Trade, they are continually aiding in the development of an amount of mineral wealth far exceeding that of any other country, and in this wholesome and important action, the movements of our body are not only unfettered, but are likely to receive all that encouragement which seems alone to be wanted to enable this establishment to be eminently useful in instructing that class of persons who will materially augment the productive industry and trade of Great Britain.

* *See* Mr. J. Kenyon Blackwell's Paper on the Present position of the Iron Industry of Great Britain, with reference to that of other Countries, read at the Society of Arts, Wednesday 9, January 1856, p. 121 of the Journal.

I have thus taken the liberty of offering to your Lordship, as the Member of Her Majesty's Government under whom I serve, my view upon a subject of which I have long thought; and have only now to request that, in giving it your best attention, you will submit this letter to Her Majesty's Government, and particularly to the consideration of the Minister who may be destined to be charged with the education of the country.

Geological Survey Office, Jermyn Street, Jan. 25, 1856.

ART. XVIII.—*Remarks on the Genus Tetradium, with Notices of the Species found in Middle Tennessee;* by Prof. J. M. SAFFORD, A. M., Geologist of the State of Tennessee.

THE genus *Tetradium*, has been characterized by Prof. Dana in his great work on Zoophytes.* His description and remarks are as follows:

"Coralla massive, consisting of 4-sided tubes, and cells with very thin septa or parietes; cells stellate with 4 narrow laminæ."

"This genus is near Receptaculites, but differs in having very thin parietes and four distinct rays within the cells, one to each side. The specimen answering to the description, is a fossil of uncertain locality in the collections of Yale College, New Haven. The cells are about half a line in breadth. The name, from the Greek, τετρας, *four*, alludes to the quadrate structure."

So far as we know, no further notice has been taken of this genus. To us it is of great interest from the fact that individuals, belonging apparently to several species, are not very abundant in the limestones of the Silurian, or as we shall hereafter term it, the *Central Basin* of Middle Tennessee.

In addition to the characters given above, we add the following: The *tubes*, in the different species, vary from $\frac{1}{4}$ of a line to nearly a line in breadth; they are very long, and are most frequently united throughout laterally, forming massive coralla resembling more or less those of Favosites and Chætetes; sometimes however, they are united in single intersecting series, as in *Halysites catenulatus*, Linn.; not unfrequently too the tubes are isolated, or only united at irregular intervals, thus forming loose fasciculated coralla resembling certain forms of Syringopora.

The *isolated tubes* are nearly quadrangular, the edges being more or less rounded. A slight linear depression down the mid-

* United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842, under the command of Charles Wilkes, U. S. N. Vol. 8th, page 701.

dle of each side externally, opposite the lamellæ. Figure 1 will serve to give an idea of the transverse, or horizontal section of one of these tubes. In the massive specimens the horizontal sections of the tubes are square, or nearly so. In all of the species the walls are more or less rugose.

1.

Separately growing tube of Tetradium; transverse section, magnified 3 or 4 times linear.

The increase appears to be by the division of the tubes, the latter splitting sometimes into two cell-tubes, not unfrequently perhaps into four; opposite laminæ unite and form the new walls of the young cells, each of which is in the mean time supplied with its four rays.

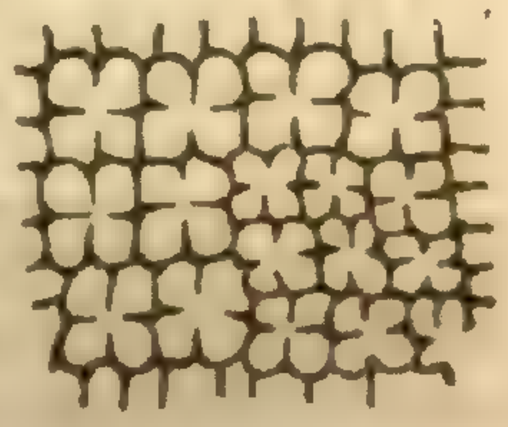
Among the numerous specimens of this genus, which we have seen, we have met with but one which shows clearly the presence of transverse septa. This is a fragmentary specimen of the first species described below. In it the septa are distant about twice the breadth of a tube; but few however are seen, and these are confined to one end of the mass.

This group we regard as being allied in some respects to the *Favositidæ*, while on the other hand, the cruciform arrangement of the lamellæ unite with the *Zoantharia rugosa* of MM. Milne Edwards and Haime; in fact it appears to afford an interesting type of the quadripartite character of the lamellæ, first pointed out, by these distinguished authors, in many palæozoic corals.

We enumerate the following species, all of which as well as the genus itself, so far as we know, are confined to the Lower Silurian rocks.

1. *Tetradium fibratum* Safford, (Fig. 2.)—Coralla massive, hemispherical, or flattened hemispherical, composed of diverging tubes. Cell-tubes four-sided with thin and slightly rugose walls; the four lamellæ distinct, nearly reaching the centre of the tubes; breadth of full-grown tubes usually about, or but little more than, half a line, varying occasionally from $\frac{1}{3}$d to $\frac{3}{4}$ths of a line. Transverse septa usually absent. A few have been seen in one specimen, which were about twice the breadth of a tube apart.

2.



Transverse section of a few tubes of T. fibratum, magnified.

This beautiful species, which may be taken as the type of the genus, occurs abundantly throughout the upper half of the Lower Silurian rocks of Middle Tennessee, associated with *Favistella stellata* Hall, *Ambonychia radiata* Hall, and other Hudson River species. Large masses a foot or two in diameter, are met with. The calcareous specimens often resemble, in a weathered longitudinal section, a fossilized but previously somewhat macerated mass of woody fibre, and hence the name of the species.

2. *T. columnare* Hall; Syn. *Chætetes columnaris* Hall. Pal. of N. Y., vol. i, p. 68, Pl. XXIII, Figs. 4, 4 a—Mr. Hall's species,

we think referable to this genus. It differs from T. fibratum in the following particulars: the tubes are not as uniformly four-sided, nor are they arranged with equal regularity; the walls are more strongly rugose; the lamellæ appear to have been more delicate, and are generally not to be seen; traces of them however can, in most instances, be found upon close examination. The four-sided character of the tubes is sufficiently well marked to justify this reference, in connection with the fact that traces of the lamellæ can often be detected.

This species is associated with the last, and occurs, in addition, lower in the series, with *Columnaria alveolata* Hall. It is a common fossil in our Central Basin.

3. *T. apertum* Safford—Tubes isolated or fasciculated, or else united in linear series which often intersect, forming irregular reticulations; breadth of tubes about half a line; lamellæ as in T. fibratum.

This species includes certain open, loosely constructed corals which belong to this genus. Two varieties may be designated. These appear to run into each other in some specimens, though it may be found necessary hereafter to separate them.

(*a*) Masses composed of separate tubes occasionally united by their sides. These forms often resemble *Syringopora.*

(*b*) Masses composed of tubes arranged in linear series, the latter intersecting and forming masses like those of *Hulysites catenulatus* Linn.

Should it be found necessary to separate these varieties, the first may be designated *T. laxum* and the second *T. apertum.*

We have observed no characters, with the exception of the open mode of growth which separate this species from *T. fibratum.*

The first variety is abundant in the middle part of the Lower Silurian series of Middle Tennessee. The second is found in the upper half as well as near the base. We have observed the same species in Kentucky.

4. *T. minus* Safford—We include in this species massive specimens, (generally small,) the tubes of which are only from $\frac{1}{4}$th to $\frac{1}{3}$d of a line in breadth. The tubes in some specimens are quite regular, in others, though generally four-sided, are more or less irregular and have the aspect on the upper surface of Chætetes. Lamellæ as in T. fibratum.

We have occasionally seen this species in the upper division of the Lower Silurian series in Middle Tennessee, as well as in Kentucky.

Art. XIX.—*A new Fossil Shell in the Connecticut River Sandstone;* by E. Hitchcock, Jr.

I have lately found in the coarse sandstone of Mount Tom, (Easthampton, Mass.,) a shell of a mollusk, the first I believe that has been discovered in the sandstone of the Connecticut Valley. It is preserved and not petrified, and a considerable part of it has disappeared. Enough remains however to enable us to refer it to a family if not to a genus of shells. It is represented in the annexed diagram of the natural size as it lies in

the rock. The upper part is gone, leaving an oval opening about an inch and three quarters in one diameter and an inch and one quarter in the other. It extends downwards, tapering somewhat rapidly nearly an inch and a half, and is left without a bottom, the lower opening being about an inch wide. The walls are very thick, in some places nearly half an inch, and made up of several concentric layers.

From the resemblance of this shell to a model of the lower valve of the Sphærulites calceoloides in the Cabinet of Amherst College, it seems probable that it may be referred to that family of Brachiopods denominated Rudistæ by Lamarck.

Its lower parts as well as the lower valve are missing, but what remains approaches nearer to the genus Sphærulites than to any other of the Rudistæ of which I have seen specimens or figures.

The geological position of this fossil will be readily understood by referring to the description of Clathropteris rectiusculus

as described in vol. xx, p. 22 of this Journal. The shell is found in the same coarse grit as the Clathropteris, immediately beneath the trap (see section in the paper just referred to).

By referring to Bronn's Lethæa Geognostica, I find that the Rudistæ with the exception of the genera—Orbicula and Crania, are confined almost wholly to the Chalk Formation, and the shell from Mount Tom certainly comes nearer to the genus Sphærulites, Radiolites and Hippurites, than to Crania.

This specimen is too imperfect to allow of a specific or generic description, but if there be no mistake in associating it with the above genera, it seems to lend additional strength to the inference derived from the discovery of the Clathropteris, that the upper part of the Sandstone of the Connecticut Valley is as high at least as the Liassic or Jurassic series. It might seem even to carry us higher in the series, but it would be premature to draw such an inference from a single imperfect specimen, even though its true analogies be ascertained. The specimen now belongs to Amherst College Cabinet.

ART. XX.—*On the Eruption at Hawaii;* by Rev. TITUS COAN.*

ERE this you may have seen my letter of Nov. 16th to Mr. Lyman, giving an account of a visit to the end of the lava stream in the forests of Hilo. Since that date I have made four trips to the fire, making six in all. The great fire fountain is still in eruption, and the terminus of the stream is only about five miles from the shore. A track for horses has been cut to the fire, so that we can now ride up with ease and return in half a day. The lava moves slowly along on the surface of the ground, and at points where the quantity of lava is small, we dip it up with an iron spoon held in the hand. During the last three weeks the stream has made no progress towards Hilo, and we begin to hope that the supply at the summit fountain has diminished. There is, however, still much smoke at the terminal crater; and while the lower end of the stream is hardened for two miles above its terminus, thus checking the flow in the forest, the fusion is by hydrostatic pressure, gushing up vertically above this line, and creeping, like fiery serpents, in a thousand gory looking rills, over the smouldering masses of lava, long since deposited. These repeated and numerous up-gushings of the fusion through cracks, holes and fissures in the superincumbent masses of recently solidified lava, are caused by the sudden hardening of the end of the stream, thus obstructing the passage and causing the incandescent material, flowing under cover from regions above, to force

* From a letter to J. D. Dana, dated Hilo, March 7, 1856.

lateral outlets, or burst again to the surface by raising the superincumbent crust into ten thousand tumuli, cracking it in every direction and tilting it at every angle. In this way, the hardened stream becomes an irregularly laminated mass of unequal thickness, with a surface rolling in ridges, raised in blisters, cones, hillocks and domes, depressed into valleys, indented with pits, rent with yawning fissures, frowning with precipices, and bristling with crags. The process is somewhat like that of a superabundant quantity of water forcing its way into too small or obstructed channels under vast fields of ice; allowing, of course, for the great difference in consistency. You will understand, that the molten flood is all poured out of the fissures on the summit and for a few miles down the slope of the mountain. At first, this disgorgement flowed down and spread wide on the surface of the mountain as blood flows down a punctured limb. This phenomenon continued until the stream had swept down some thirty miles, which it did in about two days. It now came upon a plane where the angle of slope was small, say 1°. Here its progress became slow, it spread more widely, and refrigeration was more rapid. The surface, of course, hardened first. But this refrigerating process went deeper and deeper like the congelation of water, and extended higher and higher up the mountain, until at length all the lava was covered, except at occasional vents—as heretofore described—for the escape of steam and gases. Meanwhile the molten river careered unseen under the enormous mural ceiling which had been formed of its own substance, in a continuous longitudinal stream—showing itself in fiery lines, points, rills and capes, as it gushed out from under the black crust at the terminus of the stream. Here we could deliberately note its movements, as it pushed sullenly along over the rocks, through the jungle and into the mud, the pools, and water courses. The process of breaking up vertically and spreading out afresh upon the hardened crust, was occasioned by obstructions at the end of the stream, damming up the liquid, and thus obliging the accumulating lavas to force new passages and outlets for disgorgement. In this way the stream was widened by lateral outgushings, divided into several channels, swayed to the right and left, and raised to great heights by pushing up from below, and heaping mass after mass upon what *had been* its upper stratum. Often when the stream had been flowing briskly and brilliantly at the end, it would suddenly harden and cool, and for several days remain inactive. At length, however, immense areas of the solidified lava, four, five or six miles *above* the end of the stream, are seen in motion—cones are uncapped—domes crack—hills and ridges of scoria move and clink—immense slabs of lava are raised vertically or tilted in every direction, while a

low, sullen crash, is heard from below, as if infernal spirits had risen to the surface of their fiery abyss and were there struggling to burst the adamantine ceiling of their prison and breathe the air of mortals. While you gaze in mute amazement, and feel the solid masses of rock—often 30, 50 or 70 feet thick—moving under your feet, the struggling lava oozes out, tbrough ten thousand orifices and fissures, over a field of some four or five square miles. More than once have I been on such a field, and heard, and seen and felt more than is here or can be described. And yet the action of the lava is so slow—in the conditions described—that there is no fear, and little danger to one well acquainted with such phenomena. While the timid novitiate would flee for miles before such a scene, without looking back, and without consciousness of breathing, the experienced explorer will walk deliberately among the fiery pools, and rills, pry off the caps of bursting tumuli, and dip up spoils from the incandescent rocks.

When the lava becomes obstructed so that it ceases, for a time, to flow from the *end* of the stream, then the process which has been described takes place at some point above, and the molten mass coming up at many points, and accumulating on the surface, moves down in a superincumbent stream or streams, covering up the hardened masses below, deepening the lava, and at length reaching the terminus of the former flow, pushes on into the standing forests, and continues its progress towards Hilo perhaps a mile or so, when this hardens and stops, and at length the process is repeated. Here you see the reason why Hilo has not long since been buried.

Several large tributaries of the Wailuku—the stream which empties into our bay—are blotted out, and the water of the Wailuku is greatly reduced and rendered for the present unfit for use.

Scenes of terrible splendor have been witnessed in some of our river channels, as the molten flood moved resistlessly down, displacing the water, leaping the precipices, and lighting up the banks with immense bonfires of flaming jungle. I have witnessed two scenes of the kind of inexpressible brilliancy. One on the night of the 29th of January, and the other on the 12th of February. During the former night, the molten stream poured continuously over a precipice of 50 feet, into a deep, dry basin, half filled with flood-wood. The angle down which this fire-cataract flowed, was about 75°: the lava was divided into two, three, and sometimes four channels, from one to four yards wide, and two or three feet deep. The flow was continuous down the face of this precipice from 2 P. M. on the 19th until 10 A. M. on the 30th, when we left. During the night the immense basin under the fall was filled, the precipice converted into an inclined plane

of about 4°, and the burning stream was urging its way along the rocky channel below.

But the scene on the night of the 12th of February, was, in some respects, more gorgeous still, as it combined the element of water with that of fire. A stream of lava from 20 to 40 yards wide had followed the rocky and precipitous bed of a river, until it was two miles in advance of the main lava flow, which was nearly two miles broad. Beating our way through the thicket, we came upon the terminus of this narrow stream of lava, near sunset. It was intensely active, and about to pour over a precipice of 39 feet (by measurement,) into a basin of deep water, large enough to float a ship. Before dark, the lava began to fall into the water, first in great broken masses, like clots of blood; but in a short time in continuous, incandescent streams, which increased from hour to hour in volume, in brilliancy and in rate of motion. The water boiled and raged with fearful vehemence, raising its domes and cones of ebullition ten feet high, and reflecting the red masses of fusion like a sea of fire mingled with blood.

The evaporation was rapid and sublime. From the whole surface of the basin, a vast irregular column of vapor rose and rolled upward in fleecy wreaths, and hung in a gilded and glorious canopy over the dark forest and over the fiery abyss. All night long the scene was ever changing and yet unchanged. The convolutions and gyrations were constant and inimitable. Sometimes the fleecy pillar would roll up vertically, until it seemed to form an entablature for the great dome of heaven. Again, it would career off upon the winds, like a glorious galaxy, or break up in delicate tumuli to adorn the midnight sky. We encamped on the bank of the river, about fifty feet below the fiery cataract, and exactly opposite the basin of water into which the lava was flowing, 20 feet only from its rim. The face of this precipice was an angle of about 80°, and the lava flowed down it briskly and continuously, in streams from one to four feet deep, during the night. Before morning this whole body of water, some 20 feet deep, was converted into steam, and the precipice became a gently inclined plane. In a few hours more the action ceased at this point and it has not been again renewed.

I have seen continuous lava streams flow rapidly down the sides of the mountain from 10 to probably 50 feet deep. Lava flows at any depth, or any angle, and at any rate of progress from 20 feet an hour to 40 miles.

March 17.—The lava has made no progress towards us since the date of this letter.

Art. XXI.—*On the purification of Amorphous Phosphorus*; by M. Ernest Nickles

It is known that the phosphorus not spontaneously inflammable or amorphous phosphorus (called also red or allotropic phosphorus), is obtained by heating common phosphorus for some time at a temperature between 230° and 250° C., in an atmosphere of nitrogen, hydrogen, or other gas free from oxygen. But however long the treatment be continued, a portion of the phosphorus always escapes the change and must be removed, if we would not compromise the essential qualities of the amorphous phosphorus, its innocuity and its unalterability in the air. The mode of purifying it proposed by Schrötter, its discoverer, is very inconvenient. It is based on the use of sulphuret of carbon which dissolves ordinary phosphorus without acting on the other. The process theoretically seems to be a simple one; but it is in practice attended with much trouble and danger; for the washings are not only interminable and require a large quantity of the sulphuret of carbon, but besides this, the chances of inflaming it increase rapidly with the proportions of phosphorus under treatment. M. Schrötter has from the first sought to remove the danger by recommending that the filter be kept full of the sulphuret so that the ordinary phosphorus which deposits on the borders of the filter, in a fine state of division, shall not take fire. But this precaution does not always suffice to prevent accidents.

Impressed with these difficulties while experimenting with the red phosphorus, I have sought, by a study of the distinctive qualities of the two kinds of phosphorus to arrive at a safer and more expeditious mode of preparation; and as the attempts hitherto made have appealed to methods purely chemical, I have looked more particularly to the physical properties of the two bodies. In this way, I have arrived at a process, which is both simple and rapid, and may be trusted even to inexperienced hands—the last a thing of importance since red phosphorus has become an article of commerce.

This process depends on the different specific gravities of the two kinds of phosphorus. It consists in putting the mixture into a liquid of intermediate density: thus, the specific gravity of red phosphorus is 2·106, of ordinary phosphorus 1·77; taking now a saline solution of specific gravity between these,—a solution of chlorid of calcium of 38 to 40 B., answers well the purpose,—the lighter ordinary phosphorus floats on the surface while the heavier red phosphorus remains below; and the former is readily taken up by a little sulphuret of carbon which dissolves it, so that the operation can be performed in a closed vessel.

The following are the details of the process. A little sulphuret of carbon is introduced into the retort in which the transformation has been effected. If the material, which usually adheres strongly, does not detach itself, the bottom of the retort is put into warm water. The disaggregation of the material takes place immediately, and is attended with a slight noise. As soon as the phosphorus is detached, the saline solution is added; the vessel is then closed and shaken, and at the end of ten minutes the separation of the two is accomplished. If the ordinary phosphorus is only one fourth of the whole, it may be removed entirely at a single washing in the manner explained, although it it is more prudent to make a second trial, decanting first the phosphuretted sulphuret of carbon, and adding another quantity of the pure sulphuret: and this is quite necessary if the two kinds of phosphorus are mixed in equal proportions. Three washings of this kind, will remove every trace of the ordinary phosphorus, however large the proportion.

After separating the two liquids by decantation, it is only necessary to turn upon a piece of linen cloth, the saline solution containing the red phosphorus. The purity of the product is so perfect, that it is useless to boil it with a solution of caustic potash, the common method. The whole is completed in half an hour; and what is also important, it is attended with no danger, for the operation by being carried on in a close vessel, does not allow of the vaporization of the sulphuret of carbon and a deposition of the inflammable phosphorus.

Recent observations have shown that the inhalation of the vapor of sulphuret of carbon is not without injury to the health; workmen employed in the caoutchouc manufacture have suffered severely through this means. Still this sulphuret is the best known solvent of phosphorus. The process proposed has a double advantage from this point of view, it diminishing the quantity of sulphuret of carbon used and the chances of its inhalation.

Chemists will see the value of the mode of separating solid substances of different specific gravities, mentioned above—a method not requiring heat nor a direct solvent, and being both easy and expeditious.

Art. XXII.—*Third Supplement to Dana's Mineralogy;* by the Author.*

Since the last Supplement was issued, but few new species have been proposed and several of these are of doubtful standing. The work of Professor Scacchi of Naples on the recent eruption of Vesuvius (1855) contains many facts of special interest, respecting the minerals produced at that time; and one of the varieties mentioned is an example of remarkable crystallization. The crystals are octahedrons of magnetite implanted on scoriaceous lava; but they are intersected throughout in the four cleavage directions by laminæ of hematite (specular iron). These laminæ are thin crystals and have regular facets on the edges, although so delicate as to require a glass to distinguish them. Having received specimens from Professor Scacchi, the author can attest to their perfection and the exact parallelism of the laminæ to the faces of the octahedron.

In American mineralogy, there has been the publication of some geological reports containing information on useful minerals and ores, and a few articles in the Journals. The only new minerals have been announced in a mining report, and in this volume (p. 96), by Prof. C. U. Shepard.

It is a matter of regret that mineral species are so often brought out, especially in this country, without sufficient investigation and full descriptions. It is not meeting the just demands of the science of mineralogy to say that a mineral has *probably* certain constituents, or to state the composition in a general way without a complete and detailed analysis; especially when there are no crystallographic characters to afford the species a good foundation. We have a right to demand that those who name species, should use all the means the science of the age admits of, to prove that the species is one that nature will own, for only such belong to science: and if enough of the material has not been found for a good description, there is not enough to authorize the introduction of a new name in the science. The publication of factitious species, in whatever department of science, is progress not towards truth, but into regions of error; and often much and long labor is required before the science recovers from these backward steps.

1. *List of New Works.*

Dr. Carl Friedrich Naumann (Liepzig): Elemente der theoretischen Krystallographie, 384 pp., 8vo, with 86 wood-cuts. Liepzig.—This volume is properly a supplement to the former one (Anfangsgrunde der Krystallographie) published in 1854. In that, the elements of the science are explained and the formulas for calcu-

* For Supplements I and II, see this Journal, xix, 353 (May, 1855), and xxi, 193 (March, 1856). The paging inserted beyond, refers to the Mineralogy.

lations are given. This new work gives the mathematical demonstrations, commencing with the principles of analytical geometry. The two were more conveniently incorporated in one work, in Naumann's 2nd edition of his Crystallography published in 1830. Naumann is the best author on the science of Crystallography.

———: Elemente der Mineralogie, 4th ed., 480 pp. 8vo. With 398 wood-cuts. Liepzig. 1855.

A. Dufrenoy: Traité de Minéralogie, 2me edit. considerablement augmentée. Tome 2 et Tome 5, 1ere partie, et Atlas de 80 planches. 8vo. Paris, 1856.

Chevalier Fr. von Hauer & Fr. Fœtterle: Coup d'œil geologique sur les Mines de la Monarchie Autrichienne, rédigé par order de l'Institut Impérial et Royal de Géologie, avec une introduction par M. Haidinger.—252 pp. large 8vo, Vienna, 1855.

G. H. Otto Volger: On Leuchtenbergite and its associates, Hydrargillite, Garnet, Perofskite, Magnetite, Talc-apatite, &c. Pogg. xcvi. 414 and 559. Contains observations on the analyses by other authors, with some deductions that require more investigation to give them currency.

Theodor Kjerulf (Adjunct an der Univ. Christiania): Das Christiana-Silurbecken, chemisch-geognostisch untersucht. Auf Veranstaltung des Academischen Collegiums herausgegeben von A. Strecker. 68 pp. small 4to., with a geological chart.—This work treats of the Silurian geology of Christiania, and especially from a chemical point of view, giving many analyses, (of granites, porphyries, syenites, traps, etc.) and the bearing of the subject on the origin of the rocks.

Dr. Gustav Georg Winkler: Die Pseudomorphosen des Mineralreichs. 136 pp. 8vo. München: 1856. J. Palm.—A clear and systematic review of the subject of pseudomorphism. The author recognizes two kinds of pseudomorphism: that due to *alteration* of the original material, and that due to *substitution* of one mineral for another; the first produced mainly through atmospheric agencies, infiltrating waters, and ingredients of the soil; the second through solution, the less soluble species being in solution and replacing the more soluble. He objects to regarding the instances of a change of a dimorphous substance from one state to the other (such as that of aragonite to calcite, while still retaining the aragonite form) as pseudomorphs. He also takes no notice of those pseudomorphs which arise from one mineral covering or encasing another and copying in reverse its exterior form, or from filling a cavity once occupied by a crystal. Each of these kinds merits at least brief mention in a complete work on the subject. The cubic quartz produced by incrusting or covering over fluor is a common example; the form is pseudo-crystalline: and several other pseudomorphs supposed to be produced by substitution through solution, may have been a result of this moulding process. The decomposition of pyrites leaves a cavity which another infiltrating mineral may fill, taking its form and surface strix.

A. Scacchi: Memoria sullo Incendio Vesuviano del mese di maggio 1855, fatta per incarico della R Accad. delle Sci. dai Socii G. Guarini, L. Palmieri, ed A. Scacchi, preceduta dalla relazione dell' altro incendio del 1850, fatta da A. Scacchi. 208 pp. 4to. with 6 plates. Napoli, 1855.

J. A. Hugard: Muséum d'Histoire Naturelle: Galerie de Minéralogie et de Géologie, Descriptions des Collections, Classement et Distribution des Minéraux, Roches, Terrains, et Fossiles, etc. 190 pp. 16 mo. Paris: 1855.

G. C. Swallow: First and Second Annual Reports on the Geological Survey of Missouri, 204 and 240 pp. 8vo, with plates and sections. Besides the Report of Mr. Swallow, there are also the reports of Dr. Litton and Messrs. Meek, Hawn, and B. F. Shumard. Dr. Litton is chemist to the survey, and his report contains many analyses of limestones, iron ores, etc. (vid. this Jour., xxi, 427).

Jas. M. Safford: Geological Reconnaissance of the State of Tennessee, being the author's first biennial Report. 164 pp. 8vo. Nashville, Tenn., 1856. Contains information on the ore beds or veins of the State, of Iron, Copper, Lead, Zinc.

There are four iron ore regions; (1) the *Eastern*, running through the State (Johnson, Carter, etc. Counties) in front of the Unaka group of mountains; (2) the *Dyestone region* skirting the eastern base of the Cumberland and Walden's ridge from Virginia to Georgia, including the Sequatchee and Elk valleys; (3) the *Cumberland*, associated with the coal measures, in the northern part of the State; (4) the *Western*, occupying a strip about 50 miles wide of the western part of Middle Tennessee, running from out of Kentucky to the Alabama line associated with the lower member of the carboniferous limestone. In the 1st, there are Limonite, Hematite and Magnetite ores; in the 2nd, stratified iron-stone; in the 3rd, clay iron-stone; in the 4th, limonite.—Copper ores occur at the Ducktown mine; traces are found elsewhere but no other locality of importance has been discovered.—Galena is found in various parts of East Tennessee, usually associated with blende; also in middle Tennessee.—Calamine is found in East Tennessee, and the ore of Claiborne has long been known. At several places, the mines promise to be of value.—*Gold* exists sparingly in southeast Tennessee, in Blount Co., a few miles east of Montvale Springs back of Childowee Mountain; in Monroe, on the waters of Citico creek, in the bed of Cane creek, on the head waters of Tellico river, and on those of Coco or Coqua creek, also in Polk Co. In 1847, the gold deposited at the U. S. mint amounted to $2 511; in 1848, $7,161; in 1849, $5,180; in 1851, $2,377; in 1852, $750; in 1853, $149; in all, since 1831, $46.023.

Silver glance has been found in two localities, both now doubtful. The specimen reported by Dr. Troost, according to the author, probably came from the Carboniferous limestone, on or near the Calf-killer creek.

Localities of coal, marble, hydraulic limestone, and other products are mentioned in the volume.

W. Kitchell (New Jersey State Geologist): Second Annual Report of the Geological Survey of New Jersey. 248 pp. 8vo., Trenton, 1856.—The iron and zinc mines of the State are described with much interesting detail. At Mt. Hope tunnel. Mr. Wurtz detected a mineral which he has not yet examined, but announces as probably new (p. 192).

C. U. Shepard: Report on the Canton Mine, Georgia. 20 pp. 8vo., 2nd edit. New Haven, 1856.—Contains an account of the minerals of the mine, with indications of three supposed new species called Harrisite, Hitchcockite, and Cherokine.

2. *Crystallography, Formation of Minerals, etc.*

Furnace Products: Hausmann mentions (Soc. Sci. Gott. Nov. 1855) that Manganblende occurs along with the cyano-nitrid of titanium, both in the furnaces of Gleiwitz, and the Royal Mines of Silesia; and Wöhler reports the same from the Hartz. They had been taken for magnetic iron. They occur in the scoria which forms in the working of the blast furnaces. The crystals are usually in distinct octahedrons, 4 to 5 millimeters in diameter. The color when fresh, is iron-black, and the lustre imperfectly metallic; but becoming brownish-black at surface on exposure. It differs from the native manganblende in being strongly attracted by the magnet, and also in giving the reactions of iron as well as manganese before the blowpipe. B.B. it fuses with very great difficulty to a brownish-black scoria.

On some pseudomorphs of iron ores, by E. F. Glocker, (Pogg. xcvi, 262). The paper describes pseudomorphs of hematite (specular iron) after magnetite; earthy red iron ore after hematite; limonite after magnetite; limonite after hematite, and hematite after limonite; of limonite after spathic iron; of limonite after pyrites and marcasite; of hematite after pyrites. He mentions crystals of the form of magnetite from near Schönberg in Moravia, which are altered to specular iron. The octahedrons have the cleavage of the magnetite. They are similar to the so-called martite, or octahedral specular iron of Breithaupt.

Goniometer for the measurement of angles of crystals and for optical purposes, with a plate. W. Haidinger. Pogg. xcvii, 590.

3. *Descriptions of Species.*

ALLANITE [Min. p. 208, and Suppl. I, II].—Description and analysis of Allanite from Norway, by D. Forbes and T. Dahll (Nyt. Mag. f. Nat. xiii. 213). At Helle, in crystals sometimes 4 inches long and ¾ to 1 in. thick, with quartz and mica; many of them decomposed and unaltered massive specimens have H.=6, G.=3·46—3·48.

Specimen from Näs Mine, occurring in red orthoclase, gave H.=6, G.=2·86—2·93, a greenish-black color and greenish-gray streak, and afforded on analysis:

Si	Ce	Be	Al	Fe	La, Di	Y	Ca	H	
31·03	7·24	3·71	9·29	22·98	4·35	1·02	6·39	12·24	alkali and loss 1·75

Allanite occurs at Criffel in Scotland in small crystals in syenite and feldspathic granite; *R. P. Greg, Jr.*

ALUM [p. 382].—Occurs in the caves of the Unaka Mts., Eastern Tennessee, especially at Sevier, where masses of a cubic foot may be obtained; also in the *black slate* of Middle Tennessee; in caves along the valleys and gorges of the streams in DeKalb, Coffee, Franklin, and other counties.—Safford's Rep., p. 118.

ALUNOGEN [p. 381].—Occurs at Vesuvius with alum, Scacchi, op. cit., p. 194.

A white fibrous alunogen (?) occurs abundantly at Smoky Mountain, Jackson Co., N. Carolina. According to Mr. Faber, there are tons to be blasted at that locality. —(Prof. J. C. Booth, in a letter to the author.)

ALVITE. *D. Forbes* and *T. Dahll* (Nyt. Mag. f. Nat. xiii).—From Helle and Narestö in Norway. In dimetric crystals like zircon. Fracture splintery. H.=5·5. G.=3·601—3·46. Color reddish brown, becoming grayish brown by alteration. Lustre greasy; opaque, on the edges translucent. B.B. in the platinum infusible, color somewhat paler With borax a glass greenish yellow while hot, colorless when cold. With salt of phosphorus a yellow glass, green, and finally colorless on cooling. With tin no titanium reaction. In fine powder, not attacked by the acids. An analysis of the mineral on a very small portion and part of it somewhat altered afforded

Si	Al, Be	Fe	Zr	Ce	Y	Th (?)	Ca	Cu, Sn	H	
20·33	14·11	9·66	3·92	0·27	22·01	15·13	0·40	*trace*	9·32	=97·24

ANDALUSITE [p. 257 and Suppl. I, II].—Analysis (1) of the Andalusite of Katharinenberg near Wunsiedel, (2) of Robschütz near Meissen, and (3) of Bräunsdorf near Freiberg, by E. E. Schmid, (Pogg. xcvii, 113):

	Si	Al	Fe	Ca	Mg			
1.	35·74	56·98	5·71	0·15	0·20	=	98·78	G. =3·12
2.	36·84	55·82	3·22	1·09	1·14	=	98·11	G. =3·11
3.	37·57	59·88	1·33	0·61	0·17	=	99·56	G. =3·07

Oxygen ratio for the silica and sesquioxyds (1) 2 : 3·06, (2) 2 : 2·77, (3) 2 : 2·86, corresponding nearly to the formula $\dot{Al}^3 \ddot{Si}^2$. [Allowing that the protoxyds are combined with part of the silica, Nos. 2 and 3, will give much more nearly the ratio 2 : 3.]

ANGLESITE [p. 370, and Suppl. II].—Kokscharov figures a fine crystal of Anglesite from Monte Poni, Sardinia (Min. Russl. ii, 168). He mentions the occurrence of the planes $i\breve{4}$, $1\breve{2}$; and gives the angles $I : I = 103° 43\frac{1}{2}'$, $O : 1 = 115° 35\frac{1}{2}'$.

APATITE [p. 396, and Suppl. I, II].—Occurs in New Jersey, at Mt. Pleasant Mine, near Mt. Teabo, in a low hill near the junction of the Rockaway River and the Burnt Meadow Creek, and about three-fourths of a mile from the canal. The masses are sometimes 6 inches in diameter. Apatite is also abundant with the magnetite of Byram mine.—N. J. Geol. Rep. 1856.

ARAGONITE [p. 448, and Suppl. II].—Pseudomorphs of the scaly massive carbonate of lime (called *Schaumkalk* in German) after gypsum are described by G. Rose in Pogg. Ann. xcvii, 161. Near Wiederstädt in Mansfeld, a fine-grained gypsum

contains selenite in large plates which are partly altered to this earthy carbonate. Bischof has explained the change by supposing that waters holding carbonate of soda in solution have filtrated through, producing with the gypsum sulphate of soda and carbonate of lime; but he and others have regarded the carbonate as common calcite. Prof. Rose adds to the examples of the change and shows that the carbonate is aragonite. It is generally snow-white and opaque, but minute scales are transparent; and sometimes minute crystalline tables may be distinguished. These tables have the form and angles of aragonite. Specific gravity 2 984 at 15° R.

An important paper on the groupings in the twin crystals of Aragonite, Witherite and Alstonite, by M H. de Senarmont, is contained in the Ann. de Ch. et de Phys. [3], xli, 60. The structure of the crystals was determined by means of polarized light.

ASTROPHYLLITE, *Scheerer.*—A kind of mica, from Brevig, Norway. Color black and also bronze to gold-yellow; lustre submetallic. Crystals 6-sided prisms and tables, elongated in the direction of the clinodiagonal. The angle of the prism, as usual with the micas, near 120°. Laminæ but little elastic. Contains $\breve{S}i$, $\dot{F}e$, $\dot{A}l$, $\dot{F}e$, $\dot{M}g$, $\dot{K}$, $\dot{N}a$, $\dot{M}n$, $\dot{C}a$, and about 3 per cent of water with no fluor.

ATACAMITE (?) [p. 138, and Suppl. I].—Prof. Scacchi questions the occurrence of true atacamite at Vesuvius (op. cit., p. 197). The supposed atacamite occurs (1) in slender filaments of vitreous lustre and grass green color; (2) in clustered acicular opaque crystals, between brownish green and pale bluish green; (3) in an opaque crust, with rough surface and emerald-green color; (4) in a very thin crust, of a fine emerald-green color. The first variety which seems to be the purest passes into the second.

Prof. Scacchi concludes from his various trials, that the mineral does not contain chlorine; that its composition is not constant; that ordinarily on immersing it in water, it affords an insoluble salt of a bluish color, which dissolves in nitric acid and affords reactions of sulphuric acid and copper, and may be a basic sulphate of copper.

BINNITE [Suppl. II].—This mineral which occurs with the dufrenoysite in the dolomite of Binnen, is described by Ch. Heusser, in Pogg. xcvii, 120. Crystallization, trimetric. Occurring forms prismatic, striated longitudinally, the prism *I*, having the acute edges replaced by $i\breve{i}$, and the brachydomes, $\frac{1}{2}\breve{i}$, $1\breve{i}$, $\frac{3}{2}\breve{i}$, $2\breve{i}$, with sometimes *O*, 1, $i\ddot{i}$, and a macrodome Basal angle of the dome $\frac{1}{2}\breve{i}$, 43° 52′; of $1\breve{i}$, 77° 32′; of $\frac{3}{2}\breve{i}$, 100° 38′; of $2\breve{i}$, 116° 12′. Color pale or dark steel-gray to black; streak-powder uniformly a darker red than that of the dufrenoysite; very brittle; fracture perfect conchoidal.

BORACITE [p. 393, and Suppl. II].—The massive boracite of Stassfurt, which differs from true boracite in its ready solubility in acids, and its easier fusibility, has been named *Stassfurtite* by G. Rose (Pogg xcvii, 632). The solution in heated muriatic acid deposits after a while, hydrated boracic acid. The masses are not properly structureless but have a columnar composition and the system of crystallization probably is not monometric. Chemically, boracite and stassfurtite according to the analyses, give the same formula; and if so, the two are an example of dimorphism. H. Rose has new analyses under way; and other examinations of specimens may clear up the doubts on the subject.

BORONATROCALCITE [p. 394].—Analysis of this mineral from near Iquique, S. A., by Rammelsberg (Pogg. xcvii, 301):

$\ddot{B}$	$\dot{C}a$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
43·70	13 11	6 67	0·83	35·67 = 100

3 17 p. c. of chlorid of sodium, 0·41 sulphate of soda, and 0·39 of sulphate of lime obtained in the analysis being excluded. This gives the formula $\dot{N}a\,\ddot{B}^2 + 2\dot{C}a\ddot{B}^2 + 18\,\dot{H}$. The Hayesine, similar in physical characters, which Hayes analyzed, gave him the composition $\dot{C}a\,\ddot{B}^2 + 6\dot{H}$.

BRAGITE, *D. Forbes* and *T. Dahll* (Nyt. Mag. f. Nat. xiii).—In indistinct, probably dimetric crystals, imbedded in orthoclase, and found near Helle, Narestö, Alve, and Askerö, Norway. Fracture uneven. H.=6—6·5. G.=5·13—5·36. Color

brown; streak yellowish brown. Lustre semi-metallic. Thin splinters translucent. Decrepitates strongly and loses water. B.B. in the platinum forceps infusible, but becomes yellow: with borax, a glass which is brownish yellow while hot, but green and finally greenish yellow on cooling. In salt of phosphorus, a skeleton of silica.

BREUNNERITE [p. 443].—The Tautoclin of Breithaupt, occurs (N. Jahrb. f. Min. etc., 1855, 842) in scalenohedrons, R^3, or $R^3.\frac{1}{4}R3$, as pseudomorphs after calcite. Occurs in the Himmelsfurst mine, near Freiberg; also near Sachsenburg, Schneeberg, Przibram in Bohemia, &c. Ettling obtained for the tautoclin of Beschert-Glück, near Freiberg:

Ċ 45·75 Ċa 27·48 Ṁg 15·85 Ḟe 9·25 Ṁn 1·29 = 97·62

CALCITE [p. 435, 503, and Suppl. I, II].—A variety of curved columnar calcite from Freiberg in Saxony, according to Kenngott (Pogg. xcvii, 311) has each column made up of a series of tabular crystals $-\frac{1}{2}R.\infty R$ [of the form in fig. 574 C, p. 435 of Min., only very short] united in the line of the vertical axis. The diameter is mostly 2 or 3 millimeters.—Other peculiar forms of grouping and modes of structure are described in the same paper.

CARNALLITE, *H. Rose.*—Description by H. Rose (Pogg. xcviii, 161). Occurs mixed with the stone salt of Stassfurt in coarse granular masses, having a shining somewhat greasy lustre, and sometimes showing a plane surface after the action of water over the surface, as if indicating structure or cleavage, but without any distinct traces of it in a fresh fracture. Dissolves easily in water. Composition according to Mr. Oesten, assistant to Prof. Rose:

	Mg Cl	K Cl	Na Cl	Ca Cl	Fe (mixed)	Ḣ (loss)	
1.	31·46	24·27	5·10	2·62	0·14	35 57	= 100
2.	30·51	24·27	4·55	3·01	0·14	36 26	= 100

The water by direct determination was 37·27. Part of this water is united to the chlorid of calcium, 2·54 p. c. in No. 1, and 2·91 in No. 2; so that the water of the pure mineral is reduced to about 33 per cent. The composition then becomes K Cl + Mg Cl + 12 H.

The name *Carnallite* is after Mr. von Carnall of the Prussian Mines.

CHALCOPYRITE [p. 68 and Suppl. II].—An account of the Cobre Lode of Santiago de Cuba, by D. T. Ansted, is contained in the Quart. Jour. Geol. Soc., xii, 144.

CHALYBITE [p. 444].—On the origin of the carbonate of iron in the Coal Measures, W. B. Rogers, Proc. Bost. Soc. Nat. Hist., 1855, 283, and Am. J. Sci., xxi, 339.

CHEROKINE, *C. U. Shepard.*—A species as yet imperfectly described by the author. Crystallizes like pyromorphite but has the color of carbonate of lead. Specific gravity, 4·8. Stated to contain phosphate of alumina and zinc. [The form given, near pyromorphite, would suggest the improbability that the mineral is a phosphate of a sesquoxyd with zinc, unless a pseudomorph.—J. D. D.]

CHLOROPHANERITE, *G. Jenzsch.*—From the amygdaloid in the vicinity of Weissig. It had been referred to chlorophæite, and ferruginous chlorite (Delessite), but differs in its very large percentage of silica. G. Jenzsch obtained (N. Jahrb. f. Min. etc., 1855, 798,) in a partial analysis, Silica 59·4, protoxyd of iron 12·3, water 5·7, the alumina, magnesia, lime, potash, soda, undetermined.—Color blackish-green; streak dirty apple green; soft; G. = 2 684. BB. yields easily a magnetic glass. In muriatic acid dissolves readily, the silica separating. According to Dr. Oschatz, the particles of a crystalline group magnified, showed slight double refraction. It approaches nearest a green earth from Iceland analyzed by von Waltershausen, which gave, S̈i 60·085, Ä̇l 5·280, Ċa 0·095, Ṁg 4·954, Ḟe 15·723, K̇ 5·036, Ṅa 2·514, Ḣ 4·444 = 98·131 (Vulk. Gest., p. 301).

CHRYSOLITE [p. 184. and Suppl. I, II].—A mineral looking like some kinds of amorphous garnet, occurs at Pfunders in the Tyrol, in a talcose serpentine rock traversed by veins of calcite. A specimen in the collection of M. Adam of Paris

has been analyzed by M. A. Damour and shown to be *Chrysolite.* He obtained (L'Institut, No. 1148, xxiv, 4, Jan. 1856):

	$\ddot{S}i$	$\dot{T}i$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	$\dot{H}$
	36·30	5·30	49·65	6·00	0·60	1·95=99·80
Oxygen,	18·85	2·11	19·50	1·79	0·13	1·73

The silica and magnesia have the oxygen ratio 1 : 1, as in chrysolite. But the exact condition of the titanic acid is not ascertained. [This mode of occurrence of chrysolite is analogous to that of the Boltonite (chrysolite) in granular limestone, and the Glinkite (another variety) in talcose slate. May it be that the titanium is due to a mixture with titanic iron?—D.]

Conistonite and Heddlite [p. 465, and Suppl. II].—According to R. P. Greg, Esq., in a recent letter to the author, these two species, though curious in themselves, have been found to be artificial.

Copiapite [p. 387 and Suppl. I].—Analysis of fibrous copiapite (stypticite) from Copiapo, Chili, by E. Tobler (Ann. Ch. u. Pharm. xcvi, 383): Sulphuric acid 31·49, sesquoxyd of iron 31·69, water 36·82 = 100.

Coquimbite [p. 380].—Observed rather abundantly by Scacchi about fumaroles after the eruption at Vesuvius in 1855 (op. cit., p. 195). Part of it is in a brownish friable crust; obtained by dissolving the saline crust and evaporating, in brownish-yellow *hexagonal* crystals. Also as a yellowish crust, in many parts tinged green, compact in texture, and with a very bright lustre in the fresh fracture.

Cryolite [p. 97 and Suppl. II].—J. W. Tayler, Esq., has given a description of the mode of occurrence of cryolite in Greenland, with wood cut illustrations, in the Quart. Jour. Geol. Soc. xii, 140. The locality is at Evigtok, about twelve miles from Arksut, on the Fiord of that name. The rock is gneiss and granitic gneiss. It is intersected by a vein of quartzrock containing coarsely crystallized feldspar, cryolite, and ores of iron, tin, lead, zinc, tantalum, etc., running about southwest, besides other small veins and masses of cryolite; and to the east and west there is a trap-dyke. The main mass of cryolite forms a bed or vein parallel to the strata, running nearly east and west, dipping S 45°, and is about 80 feet thick and 300 long. It is bounded along the walls by a band of spathic iron, quartz, and in some parts by fluor and galena, while near the walls in the cryolite there are more or less galena, copper and iron pyrites, etc. Tantalite and cassiterite occur in the cryolite. The galena contains 45 oz. of silver to the ton and is worked. In its lower part the cryolite is black, and the white color of the upper part is attributed to exposure to heat. The author infers "that the trap now found at each end of the cryolite has formerly overlain it, heating it superficially and rendering it white."

CYANOCHROME, *Scacchi.*—A sulphate of potash and copper, among the products of Vesuvius, at the eruption of 1855 (op. cit., p. 191).—In clear blue crystals obtained by dissolving and evaporating the saline crust, from the lava of Vesuvius; also in azure blue spots upon the white crust. Composition $(\frac{1}{2}\dot{K} + \frac{1}{2}\dot{C}u)\,\ddot{S} + 3\dot{H}$.

Form of crystals monoclinic. C (or inclination of vertical axis) = 75° 30′.

Occurring planes, O, $1i$, $2i$, ii, 1, I, $2\grave{2}$, $1\grave{i}$. $O : ii = 75° 30′$, $O : 1i = 153° 56′$, $O : 1i = 141° 47′$, $O : 2i = 116° 49′$, $I : I = 108° 12′$.

Cyanosite [p. 380].—Observed at Vesuvius by Scacchi, among the products of the eruption of 1855. Op. cit., p. 189.

Analysis of a specimen from Copiapo, Chili, by E. Tobler (Ann. Ch. u. Pharm. xcvi, 383): Sulphuric acid 32·41, oxyd of copper 30·77, water (as loss) 36·82=100. Occurs with stypticite and both results from the decomposition of chalcopyrite.

Datholite [p. 334 and Suppl. I, II].—F. Schröder has made many new measurements of Datholite crystals (Pogg. xcviii, 34), and concludes from them that the form is monoclinic, with the inclination of the axis, 90° 7′. He figures a crystal having the planes in the annexed table.

O						
$2i$				$2\grave{2}$	$2\grave{4}$	$2i$
$4i$			$4\frac{4}{3}$	$4\grave{2}$	$4\grave{4}$	$4\grave{i}$
ii		I		$i\grave{2}$		
		-4				$4i$
	$-3\frac{3}{2}$					
$-2i$		-2				$2\grave{i}$.

Andreasberg.

O				
$1i$				
$2i$				$2\grave{i}$
	$3\grave{3}$			
		4		$4i$
$6i$	$6\grave{3}$			
			$8\grave{2}$	
ii		I	$i\grave{2}$	
				$4\grave{i}$
$-2i$		-2		$2\grave{i}$
		$-\frac{4}{3}$		
		-1		
		$-\frac{3}{4}$		

American.

[The symbols, for convenience of comparison, are made to correspond with those in the Min. p. 335; by substituting for the values of the axes $a : b : c$, $2a : b : \frac{1}{2}c$, they are converted into those of Schröder. To show farther the relations of the American crystals (figs. 489, 490, 491, 493 of Min.) a table of the planes is added, the form being taken as monoclinic. In the American crystals, the prism of 115° 26′ (I) is the dominant one, while in those of Europe, that of 76° 44′ ($i\grave{2}$) is dominant.]

Schröder gives the following values to some of the angles; $I : I = 115° 19'$, $i\grave{2} : i\grave{2} = 76° 36'$, $2\grave{2} : 2\grave{2}$ (front) $= 120° 58'$, $-2 : -2$ (front) $= 131° 43'$, $O : ii = 90° 7'$, $O : 2i = 135° 3'$, $O : 2\grave{2} = 141° 7'$, $O : 2i = 147° 39'$, $O : -2 = 130° 7'$.

Diallogite [p. 446].—A variety from Oberneisen, named *Himbeerspath* by Breithaupt, and occurring in acute rhombohedrons with truncated summits, afforded A. Birnbacher (Ann. Ch. u. Pharm. xcviii, 144): Carbonate of manganese 91·31, carbonate of lime 5·71, carbonate of iron 3·06.

Dolomite [p. 441, and Suppl. i, ii], near Lettowitz, etc., Moravia, E. F. Glocker, Jahrb. k. k. geol. Reichs., 1855, 98.

Dufrenoysite [p. 77, and Suppl. i, ii].—Ch. Heusser desoribes this species anew in Pogg. xcvii. 117. Forms: the dodecahedron (I); trapezohedron (2-2); cube with the angles replaced by 2-2; cube with planes, I, 2-2; cube with planes I, 2-2. $\frac{3}{2}$; cube with planes I, 2-2, 1 (octahedron), 6-6. Color on fresh fracture black, sometimes brownish or greenish; streak cherry-red. Hardness a little above that of fluor; brittle.

Epidote [p. 206, and Suppl. ii].—Occurs in beautiful crystals at Roseville, Byram Township, Sussex Co., New Jersey.—Kitchell's Geol. Rep., p. 171.

Epsomite [p. 384].—Occurs in Tennessee, at different places, and most remarkably at the Alum Cave in Sevier, in a mountainous region on the head waters of the West Fork of Little Pigeon river. Under the shelving rock, ("rock-house") masses of nearly pure epsom salt, almost a cubic foot in volnme, have been obtained. *Safford's* Rep., p. 119.—Also found at many places in Spain especially in the province of Toledo, near Madrid.—Also formed at Vesuvius at the eruptions of 1850 and 1855. *Scacchi*, op. cit. p. 188.

ERUBESCITE [p. 38].—Analysis of ore from Coquimbo in Chili by W. Böcking (Ann. Ch. u. Pharm. xcvi, 244):—Sulphur 25·46, copper 60·80, iron 13·67=99·93.

FELDSPAR [p. 228, and Suppl. I, II].—Analyses (1 to 4) of Glassy Feldspars, by Dr. G. Lewinstein (Ueber die Zusamm. des Glas. Feldspaths, etc., Berlin, 1856). No. 1 from volcanic sand, 2, 3, 4, from trachyte and trachytic conglomerate:

	Si	Al	Fe	Ca	Mg	Na	K	
1. Rokeskill, Eifel,	66·65	18·91	—	1·49	0·76	4 45	7·74=100	G.=2·578
Oxygen,	35 28	8·83	—	0·42	0·31	1·15	1·31	
2. Perlenhardt,	[65·26]	17·62	0 91	1·05	0·88	2·49	11·79=100	
Oxygen,	33·94	8·23	0 30	0·29	0·35	0·64	1·96	
3. Drachenfels,	[65 59]	16·45	1·58	0·97	0·53	2·04	12·84=100	G.=2·60
Oxygen,	34·40	7·69	0·47	0·27	0·20	0·52	2·17	
4. Pappelsberg,	[66·03]	17·87	0·52	0·47	0·19	6·08	8·86=100	G.=2·616
Oxygen,	34·28	8·35	0·16	0·13	0·07	1·55	1·50	

In No. 3, the silica as directly determined equals 66·12.

The analyses give quite closely the orthoclase formula, $\dot{R}\,\ddot{S}i + \ddot{R}\,\ddot{S}i^3$. If the iron be taken as *protoxyd*, the analyses correspond as well to the formula $9\dot{R}\,\ddot{S}i + 7\ddot{R}\,\ddot{S}i^3$.

Ch. Heusser refers the *Hyalophan* of Waltershausen [Suppl. I], to Adularia (Pogg. xcvii, 128). It occurs in the dolomite of the Binnen valley, and agrees with that species in physical and crystallographic characters. The 2·28 p. c. of sulphuric acid found by von Waltershausen he attributes to mixture with pyrites, which is common in the rock in minute crystals. In seven different crystals examined with the blowpipe, he found no trace of sulphur. Moreover dolomite and heavy spar often occur as other impurities and partly may account for some of the results in the analysis.

The Weissigite of G. Jenzsch has afforded him (N. Jahrb. f. Min. etc. 1855, 800):

	Si	Al	Mg	Ca	K	Li	Fl, loss.
1.	65·00	19·54	1·61	0·19	12·69	0·56	0·35 =99·94
2.	65·21	19·71					0·55

The weissigite occurs in amygdaloidal cavities, in layers with chalcedony, etc. No. 1 is from the oldest or lowest of two layers, the color flesh red; G. = 2·551—2 553. No. 2 is from a second layer; color paler rose-red to reddish-white; G. = 2·533—2·553. The oxygen ratio for the protoxyds, peroxyds and silica in No. 1 is 3·15 : 9·13 : 33·75, which is near the orthoclase ratio. Part of the Weissigite No. 2 is pseudomorphous after Laumontite.

The analysis of No. 1 above comes nearest to the feldspar of Radeberg (see Suppl. II, under feldspar).

The same amygdaloidal cavities contain the chlorophanerite and the weissigite.

G. Bischof obtained (Lehrb. Geol. ii, 2171) from a feldspar pseudomorph after Laumontite from the Kilpatrick Hills (where others occur with the form of analcime also):

	Si	Al	Fe	Ca	Mg	K	Na	ign.
	62·00	20 00	0·64	0·60	*trace*	16·54	1·08	0·87= 101·72
Oxygen,	32·19	9·35	0·19	0 17		2·81	0 27	

FERGUSONITE.—See TYRITE, this Supplement.

FREISLEBENITE [p. 79].—A mineral which has been referred to Freislebenite and is probably near Bournonite, is described as new by Kenngott, in Pogg. xcviii, 165. Occurs in thin 4-sided tables (2 millimeters thick and about 12 across) of the monoclinic system, with two planes making up each margin of the table. Acute plane angle of base about 42°. H.=2 5. G =6·06. Color iron black, streak black. Brittle. B.B. fuses easily to a black shining globule and yields finally a globule of silver. The silver constitutes about 30 per cent. The charcoal becomes covered with fumes of antimony and lead, and the mineral probably consists of silver, lead, antimony, and sulphur.

GALACTITE [Suppl. I, II].—In the author's 1st supplement (this Journal, May, 1855), he pointed out that the analysis of galactite by von Hauer gave the formula of natrolite, whence, he concluded, that galactite is probably *natrolite*. Authentic specimens of the mineral have since been examined by Dr. Heddle (Phil. Mag. [4], xi, 272), and the composition of natrolite obtained in each case. The following (1, 2, 3) are his results, together with analyses of related specimens:

	Si	Al	Ca	Na	H	
1. Glenfarg, white,	48·24	27·00	0·82	14·82	9·24	= 100 12
2. " red,	47·84	27·112	4·312	11·304	10·24	= 100 808
3. Campsie Hills,	47·324	27·36	2·63	13·354	10·392	= 101 060
4. Bishoptown, white,	47·60	26·60	0·16	15·86	9·56	= 99·78
5. " pink,	47·76	27 20	0·93	14·28	9 56	= 99 72
6. Bowling, near Kilpatrick,	48·033	25·261	2 313	13·975	9·723	Fe 0 865, Mg 0·403 = 100 573
7. Dumbarton Moor,	46·96	26·908	3 76	12·83	9·50	= 99 958

GALENA [p. 39, 506, and Suppl. I, II].—A galena containing 8 7 p. c. of sulphur, and also 51·30 of sulphate of lead has been observed at Neu-Sinka, Siebenburg, and described by R Hofmann. This mechanical mixture has been called *super-sulphuretted lead* and also *Johnstonite*. Jahrb. k. k. geol. Reichs., 1855, 1.

GARNET [p. 190, and Suppl. I, II].—An analysis of the green garnet which occurs in brevicite on the island of Stokoe in the Brevig Fiord afford Dr. D. Forbes (Edinb. N. Ph. J. [2], iii, Jan. 1856):

	Si	Al	Fe	Mn	Ca	Mg	Na & loss
1.	34 96	8·73	20·55	2·40	32·69	*trace*	1·27
2.	33 84	9 18	20·31		31·92	*trace*	——
3.				23·94	30·14		

The results correspond to the formula, as Dr. Forbes states, $(\frac{1}{2}\dot{Ca}^3 + \frac{1}{2}\ddot{Fe})\,\ddot{Si} = \dot{Ca}^3\,\ddot{Si} + \ddot{Fe}\,\ddot{Si}$ = silica 35·61, lime 32·98, sesquioxyd of iron (alumina) 31·41 = 100, whence the mineral is identical in composition with melanite, notwithstanding its color. The crystals lie together, forming 6-sided prisms, or are distinct rhombic dodecahedrons. Color fine leek-green. G. (from 76 crystals at 60° F.) 3·64.

A Melanite from the Kaiserstuhl afforded Schill (G. Leonb. Min. Badens, 1855, in N. Jahrb. 1855, 838):

Si	Al	Ca	Mg	Fe	Mn	
45·80	11·00	22·10	2·00	18·25	7·70	= 99·85

[In Suppl. II, under Garnet, for Ḃi read S̈i.]

GILBERTITE [p. 223].—E. Zschau states his opinion that Gilbertite at Graupen is derived from topaz, where it occurs associated with topaz, tin ore, fluor, apatite and quartz, in gneiss; and the same he regards as probably true of the gilbertite of Altenberg, Ehrenfriedersdorf, etc.—(Letter to G. J. B., as under URDITE.)

GLASERITE [p. 365].—According to Scacchi (op. cit., p. 186) this sulphate of potash, which is not common at Vesuvius, was rather abundant at the eruption of 1848, and occurred sparingly in that of 1855.

GUANO.—Prof. C. U. Shepard has given names to different portions of the hardened or "petrified" guano of Monk's Island, in the Caribbean Sea (Am. J. Sci., [2], xxii, 96) calling them collectively *pyroguanite* minerals. He remarks that the guano has "been subjected to the agency of heated trap rock, whereby the greater portion of it has been thoroughly fused." [The guano overlies and incrusts trap. But this appearance of fusion is merely a result of the consolidation and concretion through infiltrating waters. The same kind covers unhardened guano.—J. D. D.]

The tuberose and reniform massive guano material of a grayish white to brownish color, he has named *pyroclasite*, the name alluding to its flying to pieces when heated. H.=4. G.=2·36—2·4. "It consists of not far from 80 p. c. of phosphate of lime and 10 p. c. of water; while the remainder is made up of a little insoluble matter, carbonate of lime, sulphate of lime, sulphate of soda and traces of chlorid of sodium and fluorine." [The analyses by others give varying results.]

Another of the so-called species is named *Glaubapatite.* It is described as occurring in small tabular crystals, and in druses, forming botryoidal and stalactitic masses, with columnar radiating flattened fibres; also massive; color pale yellowish or greenish-brown; translucent; H.=3·5; G.=2·6. Also chocolate-brown to nearly black when massive. Chemical examination afforded, Phosphate of lime 74·00, sulphate of soda 15·10, water 10·30, organic matter, sulphate of lime and chlorid of sodium, *a trace* =99·40. [From the composition obtained, it can hardly be a chemical compound.]

Epiglaubite is the name of the third guano product. It occurs "in small aggregates or interlaced masses of minute semitransparent crystals of a shining vitreous lustre, which are always implanted upon druses of *glaubapatite.* H. about 2·5." It is stated to be "a largely hydrated phosphate, chiefly of lime, and may also contain magnesia and soda." Soluble in dilute muriatic acid. B.B. fuses easily to a semitransparent colorless glass tinging the flame green.

Gypsum [p. 377, and Suppl. II].—Gray's Cave, Sumner Co., Tennessee, affords fine specimens of selenite, snowy gypsum, and "alabaster rosettes."—Safford's Rep., p. 119.

HARRISITE, *C. U. Shepard.*—A sulphuret of copper, like copper glance in composition but cubic in cleavage like the artificial sulphuret. Occurs in imperfectly formed cubes and octahedrons, and also disseminated in seams and massive. Color grayish-black. G.=5·4. Occurs at the Canton Mine, Georgia, with galena in quartz and also crystals of staurotide. A mass of 50 lbs. has been got out.—(Rep. on Canton Mine.)

Heddlite.—See under Conistonite.

Hematite or Specular Iron [p. 113, and Suppl. II].—Scacchi has made observations on the hematite of the last eruption of Vesuvius (1855).—[Op. cit. p. 172]. He finds the hematite in crystals and also stalactites and incrustations on the scoria about the small cone. Among them are brilliant crystals, rhombohedrons, of 86° 51′, and double hexagonal pyramids having the faces inclined to a plane truncating the summit 141° 48′. There are also exceedingly thin scales or laminæ which are a lively blood red by transmitted light.

Besides these, there are octahedral crystals, some with their edges truncated, which are very brilliant, and according to exact measurement the octahedrons are regular or monometric. These octahedrons are intersected, often intricately so, by microscopic laminæ which cut through parallel to the octahedral faces, and these laminæ consist of hematite or specular iron, being crystalline plates flattened parallel to O ($0R$), and having on their edges faces of R and other planes of this species. These faces R are so exceedingly minute that M. Scacchi has not been able to ascertain any definite relation in position to those of the octahedron.

The specular iron of the lava, has often some magnetic qualities. A lamellar variety of the eruption of May, 1855, does not affect the magnetic needle, but manifests sensibly polar magnetism with the magnetoscope. Rhombohedral crystals with truncated summits, from the valley of Cancherone, and bipyramidal crystals from either Somma or Vesuvius (the locality being uncertain) are sensibly magnetic with the needle, and magnetipolar with the magnetoscope. A group of octahedral crystals from the same valley, united on a crust of hematite, is notably magnetic and magnetipolar. Octahedral crystals intersected by lamellæ of hematite are strongly magnetic and sensibly magnetipolar. The stalactites of hematite vary much in magnetic qualities.

Prof. Scacchi questions whether any of the crystals are pseudomorphs, and whether they are magnetite altered to hematite or hematite to magnetite. He says the first is not probable, as hematite is the usual product of sublimation about the volcano; and the second cannot be, as the crystals then should be all rhombohedral. Perhaps, he says, the sesquioxyd of iron is dimorphous: but on this point more evidence is required.

HITCHCOCKITE, *C. U. Shepard.*—No description given, except as follows (Rep. on Canton (Ga.) Mine, 1856)—a white earthy shell, sometimes no thicker than a mere varnish, on marcasite, at a mine affording galena, copper pyrites, blende, mispickel, automolite. "It is a hydrated phosphate of alumina with oxyd of zinc."

HORNBLENDE [p. 170, and Suppl. I, II].—Crystallographic and optical relations to pyroxene, *W. Haidinger*, Sitzungsb. Akad., Wien, xvii, 456.—An important paper.

LANTHANITE [p. 456, and Suppl. I].—Reported by Prof. C. U. Shepard as observed at the Canton Mine, Georgia (Rep. 1856), "at one spot in the 96 feet level, where it was found in very beautiful pink-colord crystals, lining small cavities of botryoidal white iron-pyrites."

LEAD [p. 17].—Native lead and lead ochre are reported as occurring at Zomelahuacan in the state of Vera Cruz, in a communication by M. Nöggerath (Zeits. d. geol. Ges., vi, 674). The locality is a valley over 3000 feet deep whose upper rocks are porphyry, melaphyre and basalt, trachyte, with metamorphic limestone and other beds below. The limestone in some parts still retains fossils, as *Ammonites Bucklandi* and *Ampullaria angulata*. The formation is 900 feet thick. The native lead and ochre occur in a white granular limestone. The lead ochre is somewhat foliated, of a wax or reddish yellow color to reddish where in contact with the native lead.

The amygdaloid from near Weissig, according to G. Jenzsch, sometimes contains in its cavities native lead, overlying pyrites, weissigite, chalcedony, quartz, galena, hornstone, &c.—Jahrb. f. Min. 1855, 805.

Native lead is stated to occur also in the Altai (v. Hingenau's Oest. Zeits. 1854, in N. Jahrb. f. Min. etc. 1855, 837) seven miles from Mt. Alatau in the gold region. It is described as accompanying limonite, magnetite, and galena, in irregular masses a drachm in weight. Grains of native lead are also found with the gold near Ekatherinenburg in the Urals.

LEUCITE [p. 231].—The leucite of the modern lavas of Vesuvius, according to Deville (L'Institut, No. 1173), contains much more soda than that of the old lavas of Somma. The oxygen ratio for the soda and potash in the former is 1 : 2·09 for the crystals from the lava of 1855, and 1 : 8·21 for those from the old lavas of Somma (Fossa Grande). The same for the lavas of 1847, according to Damour, is 1 : 1·67.

Rammelsberg (Monatsb. Preuss. Akad. March, 1856, 148) has published a short paper on leucite and its pseudomorphs, remarking on the occurrence of a large proportion of soda in the altered leucite (2 of soda to 3 of potash).

LEUCOPYRITE [p. 61, 507].—Composition by G. A. Behncke (Pogg. xcviii, 187):

		S	As	Sb	Fe
1. Geyer,	G.=6·246—6·321,	6·07	58·94	1·37	32·92=99·30
2. Breitenbrunn,	G.=7·282—7·259,	1·10	69·85	1·05	27·41=99·41

Regarding the sulphur as being combined with part of the iron and arsenic as mispickel, the analyses, this excluded, become—the 1st, arsenic 67·06, iron 32·94=$Fe^3 As^3$; the 2nd, arsenic 72·19, iron 27·71=$Fe As^3$.

KEILHAUITE [p. 341, and Suppl. I].—D. Forbes and T. Dahll (Nyt. Mag. f. Nat. xiii,) mention the occurrence of masses of Keilhauite weighing 15 to 20 pounds, at Alve in Norway. H.=6·5. G.=3·72. Two perfect cleavages cross at 138°. Color dull brown. Streak pale dirty yellow. B.B infusible and unchanged. Specimen from near Narestö had G.=3·519; and a pale grayish brown, from Alve, G.=3·603.

In the Edinb. N. Ph. J., [2], iii, Jan. 1856, Dr. D. Forbes states that the percentage of titanic acid should read 28·04, instead of 28·84. A comparison of the angles of the crystals with those of sphene, made by Professor Miller of Cambridge, is here given.

KILLINITE [p. 170].—Analyses by Rev. J. A. Galbraith (J. Geol. Soc. Dublin, vi, 165):

		$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$	$\dot{N}a$	$\dot{H}$
1. Dalkey Quarry, Co. Dublin,		59·11	29·37	2·23	0·34	1·03	6·71	0·60	8·03=98·42
2. Killiney,		50·45	30·13	3·53	——	1·09	4·81	0·95	7·53=98·54

The first gives the oxygen ration for $\dot{R}$, $\ddot{R}$, $\ddot{S}i$ and $\dot{H}$. 1 : 5·97 : 11·53 : 3·10; and the second, 1 : 6·18 : 11·76 : 2·96; which Mr. Galbraith takes at 1 : 6 : 12 : 3, and writes the formula $\dot{R}\,\ddot{S}i + \ddot{A}l^2\ddot{S}i^3 + 3\dot{H}$. The results agree very nearly with those of Lehunt and Blyth, and differ from the analysis of Mallet [see Min. p. 170]. Specific gravity

of No. 1, 2·678; of the same in fragments 2·688. Lithia was carefully looked for, and none found.

Magnesite [p. 441, 507, and Suppl. II].—Occurs in crystalline schist near Bruck in Styria, according to Fr. Foetterle (Jahrb. k. k. geol. Reichs., 1855, 68). Analysis afforded. $\dot{M}g\,\breve{C}$ 99·22, $\dot{F}e\,\breve{C}$ 0·69, $\dot{C}a\,\breve{C}$ *trace*, insoluble 0·09; another of the same, 94·77, 1·54, 0·86, 2·83. Specific gravity =3·033. H.=4·5. R : R=107° 16′.

Marcasite [p. 60].—An analysis of a specimen from the Oxford clay near Hannover, afforded Dr. A. Vogel, Jr. (N. Jahrb. f. Min. etc., 1855, 676), Sulphur 52·7, iron 46·9=99·6.

Mispickel [p. 62, 509, and Suppl. I, II].—Analyses by G. A. Behncke, in the laboratory of Prof. H. Rose (Pogg. xcviii, 184):

		As	Sb	S	Fe
1. Sahla, Sweden,	G.=5·8205,	42·05	1·10	18·52	37·65 = 99·32
2. Altenberg, Silesia,	G.=6·042,	43·78	1·05	20·25	34·35 = 99·43
3. Freiberg, Saxony,	G.=6·046,	44·83	——	20·38	44·32 = 99·53
4. Landeshuth, Silesia,	G.=6·067—6·106,	44·02	0·92	19·77	34·83 = 99·54

Sb in 1, with trace of Bismuth; in 2, trace of copper; in 4, trace of copper and lead.

The first three analyses correspond closely to the received formula $Fe\,As^2+Fe\,S^2$. For No. 4, Mr. Behncke writes the formula $3Fe\,S^2+2Fe^2\,As^3$. But it has the same crystalline form as the true mispickel, and the peculiar composition may therefore be due to impurities.

An ore related to mispickel, from Zwiesel, having G.=6·21, afforded Dr. A. Vogel, Jr., on analysis (N. Jahrb. f. Min. etc. 1855, 674), Arsenic 54·70, sulphur 7·44, iron 35·20=97·34. This is near the result of Jordan's analysis of an ore from the mine Felicitas of Andreasberg, which gave, Arsenic 55·00, iron 36·43, sulphur 8·34=99·79. It gives the formula $Fe\,S+Fe^2\,As^3$, while that of ordinary mispickel is $Fe\,S^2+Fe\,As^2$, and therefore the author regards it as a distinct species.

Nitre [p. 433, and Suppl. I].—The nitre caves of Tennessee occur along the limestone slopes and in the gorges of the Cumberland table-land. A company is formed for working the nitrous earth in White County.—Safford's Rep., p. 117.

Opal [p. 151].—According to E. F. Glocker, in Luckau, Moravia, a metamorphic limestone associated with gneiss contains a bed of brown hornstone and green opal (Jahrb. k. k. geol. Reichs., 1855, 98). The hornstone bed is 2 to 4 feet thick, and in some parts contains cavities with quartz crystals. The opal has a beautiful leek-green color, passing into yellow, brown and black, and occurs in a layer ½ to 2 inches thick. *Unghwarite* is sparingly associated with the opal; and occasionally pellucid hyalite is found in grouped concretions in a calc sinter.

Ozocerite [p. 474, and Suppl. I].—In the Carpathian sandstone formation.—Glocker, Jahrb. k. k. geol. Reichs., 1855, 101.

PATERAITE.—A sulphuret of molybdenum containing 3 of sulphur to 1 of molybdenum ($Mo\,S^3$), has been thus named by Haidinger.—E. Zschau, in a letter to G. J. Brush.

Pectolite [p. 305, and Suppl. II].—Radiated crystallizations of pectolite occur in Ayrshire, having the columns 3 feet in length.—R. P. Greg, Jr.

Piauzite [p. 469].—According to Kenngott, occurs at Mount Chum near Tuffer in Styria; and near Tuffer, 3700 pounds (avoirdupois) have been obtained. It is a black resin much resembling a slaty and lamellar black coal.—Jahrb. k. k. geol. Reichsanst., 1855.

PICROMERID, *Scacchi*.—A sulphate of magnesia and copper, $(\dot{M}g.\,\dot{C}u)\,\ddot{\ddot{S}}+3\dot{H}$, obtained with the cyanochrome of Vesuvius from solution, and similar in form, the two being isomorphous, but color white. Angles: C or $O : ii$=75° 12′, $O : 1i$=154° 39′, $O : 2i$=116° 41′, $I : I$=109° 50′.—Op. cit., p. 191.

Pinguite [p. 338].—At Sternberg in Moravia.—Glocker, Jahrb. k. k. geol. Reichs., 1855, 99.

PLATINUM [p. 12, and Suppl. I, II].—Composition of the platinum of Borneo, by Max Böcking of Bonn (Ann. Ch. u. Pharm., xcvi, 243):—Platinum 82·60, iridium 0·66, osmium 0·30, gold 0·20, iron 10·67, copper 0·13, iridosmine 3 80=98 36. It occurs with grains of iridosmine, gold, chromic iron, magnetite. Among the platinum grains, there are some octahedrons of very regular form and also the cube.

PYROMELANE, *C. U. Shepard*, Am. J. Sci., [2], xxii, 96.—Found in grains or kernels among the sands at the gold washings of McDonald Co, N. C.; the grains irregular and pitted, looking somewhat like those of chondrodite. H. = 6·5; G. = 3·87; color reddish-brown to nearly black; translucent; lustre resinous to resino-vitreous.

Composition undetermined, no analyses being given. Said to be "essentially a titanate of alumina and iron, with only traces of glucina? and lime. It may also contain zirconia."

PYROSCLERITE [p 291.]—The steatite-like mineral from Snarum occurring with the Völknerite, partly resembling a talc and partly a mica, which has been analysed by Hochstetter and Giratowski, is the subject of a note by Rammelsberg (Pogg. xcvii, 300), who has analysed a specimen named mica from the same place. The analyses give—

	Si	Al	Fe	Mg	H	
1.	32·03	12·52	4·48	37·52	16·19 = 102·74,	*Hochstetter.*
2.	30·02	13·2	3·1	37·9	17·0 = 101·4,	*Giratowski.*
3.	34 88	12·48	5·81	34·02	13·68 = 100·87,	*Rammelsberg.*

The last (and the others nearly correspond) give the oxygen ratio for Ṙ. R̈, S̈i, Ḣ, 13 37 : 7·57 : 18 12 : 12·16 = 2 : 1 : 3 : 2, and afford the formula $2\dot{M}g^3\ddot{S}i + \ddot{A}l\ddot{S}i + 6\dot{H}$, the formula deduced by Hartwell for the Kæmmererite of Bissersk. [The Voigtite, beyond, appears to be related to this compound.]

QUARTZ [p. 145, and Suppl. II.]—Capillary crystals, some an inch long, occur not far from Walchow, Moravia.—Glocker, Jahrb k. k. geol. Reichs., 1855, 100.

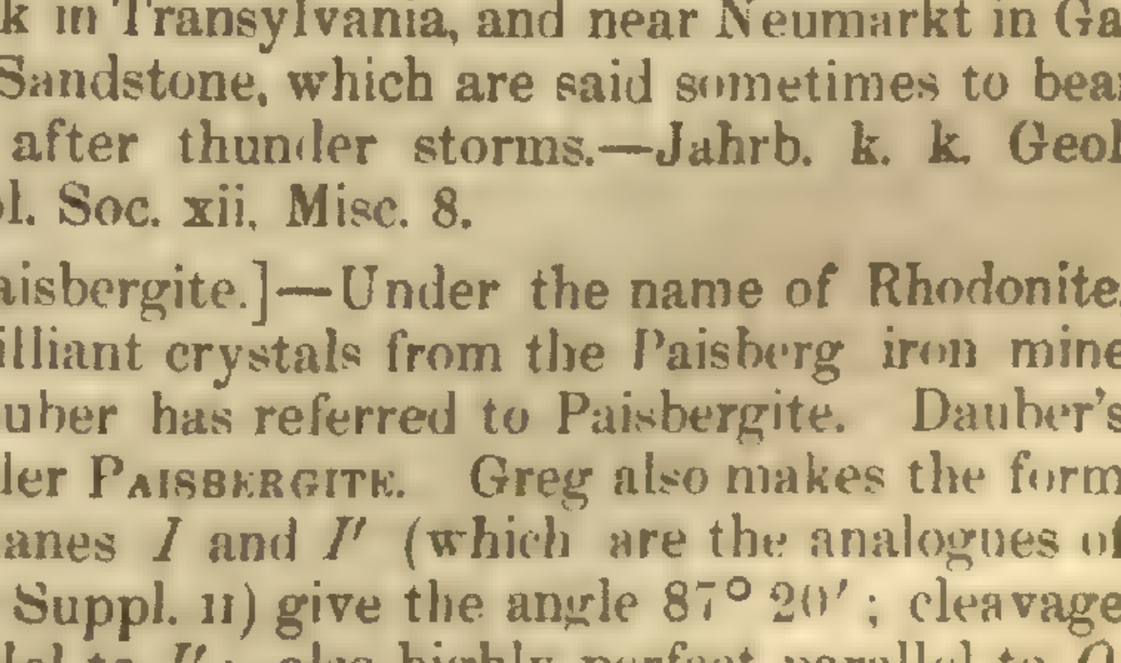
A singular compound structure in a crystal of quartz is described and figured by Kenngott (Pogg. xcvii, 628). A single hexagonal prism terminates in 6 prisms which coalesce across the centre so as to make a regular star of six rays.

QUICKSILVER [p. 14.]—Near Cividale, not far from Gagliano, in Venetian Lombardy, native quicksilver has been found in marl, connected with the "macigno," regarded as a part of the eocene nummulitic formation. Quicksilver in drift deposits has been found at Sulbeck near Luneburg, at Illye west of Deva in Transylvania, and at Montpelier. Near Eszbetek in Transylvania, and near Neumarkt in Galicia, springs issue from the Carpathian Sandstone, which are said sometimes to bear along globules of mercury, especially after thunder storms.—Jahrb. k. k. Geol. Reichsanst., Nov. 1855, in Quart. J. Geol. Soc. xii, Misc. 8.

RHODONITE [p. 167, and Suppl. II, Paisbergite.]—Under the name of Rhodonite, R. P. Greg, Esq., has described some brilliant crystals from the Paisberg iron mine near Phillipstadt in Sweden, which Dauber has referred to Paisbergite. Dauber's measurements are given in Suppl. II, under PAISBERGITE. Greg also makes the form triclinic, though near pyroxene. The planes *I* and *I′* (which are the analogues of the fundamental prism of pyroxene, see Suppl. II) give the angle 87° 20′; cleavage highly perfect parallel to *I*, less so parallel to *I′*; also highly perfect parallel to *O*.

Angles according to Greg, to which those obtained by Dauber and the corresponding angles of pyroxene are added:—

	Greg.	Dauber.	In Pyroxene.
I : *I*	87° 20′	87° 38′	87° 5′
O : *I*	93° 50′	93° 28½′	100° 57′
O : *I′*	110° 40′	111° 8½′	100° 57′
I : ĭ̆	136° 20′	136° 8½′	133° 32⅓′
I : *ĭ*	138° 20′	138° 11½′	136° 27⅓′
I : −2	148° 42′	148° 47′	144° 35′
I′ : −2′	142° 30′	142° 39½′	144° 35′
I : −2′	86° 35′	85° 24′	



[Figure 1 is derived from Greg's figure. It represents the crystal flattened parallel to *I*. Figure 2 is the normal form of the crystals, and corresponds closely to Dauber's crystals as represented by him.

It remains to be ascertained whether there is any Rhodonite with a monoclinic form; in other words, whether Fowlerite or Paisbergite is not true Rhodonite.]

Sal-ammoniac [p. 92.]—Reported by Scacchi as formed at Vesuvius at the eruptions of 1855, but, as usual, where the lava has spread over soil with vegetation. It sometimes presented the form of the rhombic dodecahedron with cavernous faces: in 1850, it occurred in twins.

Salt [p 90, and Suppl. II.]—Announced by Scacchi as among the products of the Vesuvian eruption of 1855, (Op. cit., p. 183,) occurring at a small cone of eruption. in small cubes, incrustations, stalactites. Some *chlorid of potassium*, and also *sulphate of potassa* exists with the common salt in the stalactites. Scacchi also announces the probable occurrence of *chlorid of magnesium* in the saline crusts, together with the *chlorid of manganese.* The last was detected among the saline products of the eruption of 1855 (op. cit., p. 181.) It was detected in the crust by treating it with distilled water and testing with ferrocyanid of potassium, when the white precipitate thrown down acquired after a while a pale rose tint. Other trials also were made.

Serpentine [p. 282, 511 and Suppl. I, II.]—The Serpentine Rock of Roxbury and other places, Vermont. has been analyzed by A. A. Hayes (Proc. Bost. Soc N H., Dec. 1855, and July 1856, and Am. J. Sci., xxi, 382), and shown to consist largely of carbonate of magnesia; the associated white spar is this species pure. He regards the rock as made up of this carbonate along with different silicates. An average of the rock of Roxbury afforded 38·00 of the carbonate and 62·00 of associated minerals. The rock of Proctorsville, Vt., gave 33·45 of $\dot{M}g\ddot{C}$, leaving 66·55 for the rest, consisting of $\ddot{S}i$ 36·10, $\dot{M}g$ 18·70, Fe, Mn, O, 3·40, $\ddot{A}l$ 1·13, chromic iron 0·92, $\dot{H}$ 6·21=99·91. In another specimen of the same, the proportions of magnesite to the rest was 26·40 : 73·60.—The magnesite is attacked by muriatic acid with great difficulty.

The same serpentines had been previously examined by Dr. Jackson, who states and still holds (Proc. Bost. Soc. N. H., Feb. and July, 1856) that excluding the veins and some admixture of carbonate of magnesia, the serpentine has the usual composition, being a hydrous silicate of magnesia.

Silver [p. 15].—A few filaments of native silver observed at a copper mine a mile from the Cheshire barytes mine, Ct.—S. Smith, in Proc. Amer. Assoc., ix, 188.

Smithsonite [p. 447, and Suppl. I]—Pseudomorphs of Smithsonite having the form of dolomite, have been observed at the Lancaster zinc mines.—W. J. Taylor, Am. J. Sci., [2], xxi, 427.

Sphene [p. 268].—A pulverulent decomposed sphene affording reactions for water (12·5 per cent) and titanic acid, has been named *Xanthitane* by C. U. Shepard (Am. J. Sci. [2], xxii, 96). The color pale yellowish white; lustre feeble; brittle; hardness = 3·5; G = 2·7—3·0 No analysis has been made. Found in a decomposing feldspar, associated with zircon, at Green river, Henderson Co., N. C.

Stannite [p. 512.]—Analysis by Bischof (Chem. u. phys. Geol., ii, 2026).

$\ddot{S}i$	$\ddot{S}n$	$\ddot{A}l$	$\dot{F}e$	$\dot{C}a$	ign.
51·57	38·91	4·53	3·55	0·16	0·43 = 99·15

It appears hence to be a mixture of different substances. It is probably a pseudomorph after feldspar, in which tin ore has replaced much of the original ingredients. It occurs massive, with a small conchoidal fracture.

Staurotide [p. 261].—Found at the Lead mine, Canton, Georgia, in the quartz or quartzose mica slate which is the gangue of the vein, sometimes penetrating the pyrites and copper ore. The crystals are "rarely thicker than a large-sized needle." Prof. Shepard says that they appear to be identical with the Partschin of Haidinger, (see Suppl. I) [but partschin is a very different mineral from staurotide, having the garnet oxygen ratio.]

STIBNITE or Stibine (Antimony Glance) [p. 33].—Occurs in Katharinenburg in the Urals. Kokscharov, Min. Russl. ii, 163.

STILBITE [p. 332].—A mineral related to Stilbite has been described by J. W. Mallet (this Journ. xxii, 179). Coarse granular massive, grains cleavable, pearly on two opposite faces, monoclinic?, hardness a little above that of calcite, G.=2·252. With strong muriatic acid yields a jelly. Composition—

$\ddot{S}i$	$\ddot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$, little $\dot{N}a$	$\dot{H}$
53·95	20·13	12·86	*trace*	0·87	12·42=100·23

corresponding nearly to $\dot{C}a\,\ddot{S}i + \ddot{A}l\,\ddot{S}i^2 + 3\frac{1}{2}\dot{H}$.—From the Isle of Skye, Scotland.

STILPNOMELANE [p. 287].—Observed by E. F. Glocker, in Moravia and Eastern Silesia, at Seitendorf near Troppau, Bärn, two miles from Sternberg in Moravia, at Sternberg, and at Liskowitz and Wächtersdorf, and Jessenetz. The rock containing it is clay slate or argillite, probably of Devonian age. It is often associated with chlorite, calcite, and magnetite, and sometimes with pyrites and limonite. Chlorite especially is its common attendant, and the two have close resemblances, so that when mixed they are distinguished with some difficulty.

TANTALITE [p. 351].—Tantalite from Chanteloube in Limoges, has given Dr. G. Jenzsch the following composition (Pogg. xcvii, 104):

	$\ddot{T}a$	$\ddot{Z}r$	$\ddot{S}n$	$\dot{F}e$	$\dot{M}n$		
1.	83·55	1·54	1·02	14·48	*tr.*	=100·59	G.=7·703
2.	78·98	5·72	2·36	$\dot{F}e$ 13·62	*tr.*	=100 68	G.=7·027—7·042

The second analysis is of specimens partially altered by exposure. The fresh pieces have a conchoidal fracture, submetallic adamantine lustre. H.=6·5, streak iron-black to blackish-brown. The specimens analyzed had been received by H. Rose from M. Damour.

THENARDITE [p. 365].—Scacchi has described (loc. cit.) an anhydrous sulphate of soda under the name of *pyrotechnite*, (alluding to its volcanic origin) found on the scoria of the eruption at Vesuvius of 1855. On being dissolved and evaporated, octahedral trimetric crystals were obtained. Calling the planes of the octahedron 1, the planes are I, $1\breve{1}$, 1, $3\breve{3}$; and the angles $I : I$=118° 37′, $1\breve{1} : 1\breve{1}$ (over base) 128° 58′, 1 : 1, basal, =135° 21′, pyramidal 123° 39′ and 74° 36′, $3\breve{3} : 3\breve{3}$ basal, =153° 41′, pyramidal 63° 48′ and 123° 2′. [The planes and angles are those of Thenardite, a described octahedron of which has the angles, 135° 41, 123° 43′ and 74° 18′. See Brooke and Miller's Min., p. 534. The angles in the author's Min., are from Hausmann.—J. D. D.]

TRITOMITE [p. 311].—According to Dr. D. Forbes, the crystallization of tritomite is doubtful (Edinb. N. Ph. J., [2], iii, Jan. 1856). G.=3·908. Composition according to his analysis:

$\ddot{S}i$	$\dddot{W}$ (with $\ddot{S}n$)	$\ddot{A}l$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{Y}$	$\dot{L}a$	$\dot{C}e$	$\dot{F}e$	$\dot{M}n$	$\dot{H}$
21·16	3·95	2·86	4·04	0·09	0·33	4·64	12 41	37·64	2·68	1·10	8·68=99·58

Dr. Forbes states that the received formula $\ddot{R}\,\ddot{S}i + 2\dot{H}$ is probably as correct as any other which can at present be proposed.

TSCHEFFKINITE [p. 341].—Description by Kokscharov in Min. Russl. ii, 150. He states that he knows of five specimens of the mineral, and that most of the so-called Tscheffkinite is Ural-orthite.

TYRITE [Suppl. i].—This species, described by D. Forbes, is referred to Fergusonite by A. Kenngott (Pogg. xcvii, 622). His specimens were received from Dr. Bondi of Dresden, who suggested on sending them a possible relation to that species. They were from Helle and Tromsöe near Arendal. One of them is a portion of a crystal sufficient to establish its hemihedral dimetric character and a correspondence in the occurring planes, these planes being O, 1, $3\frac{3}{2}$ [figure in Min., p. 350], and giving, as nearly as can be determined, the same angles. Haidinger describes Fergusonite as

having traces of a basal cleavage. These crystals show no distinct traces. Color brownish-black. Lustre between submetallic and waxy. Thin splinters a yellowish brown translucence on the edge. Streak pale grayish brown. H.=6·0. G=5 555; another piece 5·100, which is below that of fergusonite for which Allan obtained 5·838, and Turner 5·800. The tyrite strongly decrepitates before the blowpipe while the fergusonite only very slightly so.

The evidence from form and most of the physical characters is so strong that we can hardly doubt the identity.

URDITE, *D. Forbes* and *T. Dahll* (Nyt. Mag. f. Nat. xiii).—Occurs in granite near Nöterö in Norway. Crystals clinohedral. Color yellowish-brown to brown; streak pale grayish-yellow. Lustre greasy. Subtranslucent. G. of a fragment of a crystal 5·204, 5·19, 5·26. In a tube no water. BB. infusible, but glows and color becomes darker on cooling; with borax in the reducing flame, a glass which is yellow, somewhat greenish while hot, and colorless on cooling; with salt of phosphorus, a skeleton of silica. No reaction of titanium or manganese. On charcoal affords a white metal (tin?). Powder not attacked by hot muriatic acid.

According to E. Zschau, (letter addressed to G. J. Brush, dated Dresden, March 9, 1856,) the *Urdite* has the form of monazite, and is that species; he states that he has recognized the planes of Monazite, *I*, *ii*, $-1i$, -1, *O*, $2i$, and $2\grave{2}$ [see Min., p. 402.] The crystal is about an inch in length and breadth, and half an inch in thickness; its weight 20·5 grammes. It occurs in feldspar (in granite intersecting gneiss), and also enveloped in orthite.

VANADINITE [p. 362, and Suppl. II].—According to Rammelsberg, (Monatsb. Preuss. Akad., March 1856, 153), the Vanadinite of Mt. Obir near Windisch-Kappel in Carinthia, affords for the angle of pyramid (1 : 1 over terminal edge) 142° 30′. The same angle in mimetene, according to G. Rose, is 142° 7′; in pyromorphite, 142° 15′; in apatite, 142° 20′. Hence phosphoric and vanadic acids appear to be isomorphous.

VIVIANITE [p. 415].—Analyses of earthy vivianite (Eisenlasur), by H. Struve (Bull. St. Petersb., Class. Phys.-math., xiv, 171–173):

P̄	F̄e	Ḟe	Ḣ		
29·17	21·34	21·54	27·50		= 99·55
19·79	33 11	13·75	26 10,	Ṁg 7·37	= 100·12

Found in crystals, perfectly colorless when first obtained, in the greensand, near Middletown, Newcastle Co., Delaware.—Prof. J. C. Booth in lit.

Observed in human bones.—Nicklès, Am. J. Sci., [2], xxi, 402.

VOIGTITE.—This new mineral, described by E. E. Schmid (Pogg. xcvii, 108), is from Ehrenberg, near Ilmenau. It resembles a mica, and is disseminated in granite, replacing true mica. The granite is partly graphic granite. In oblong scales, seldom over 1 millimeter thick, micaceous in structure; color leek green, and thin scales translucent, though often yellowish or brown and opaque from alteration; lustre pearly; hardness somewhat above 2; sp. gr. 2·91. In a glass tube yields water, exfoliates, and becomes dark brown and metallic in lustre. BB. fuses easily to a black glass; and gives the reaction of iron. Attacked by cold muriatic acid, giving a yellow solution, and the insoluble part becomes after a few days colorless. Composition:

S̄i	Ǟl	F̄e	Ḟe	Ṁg	Ċa	Ṅa	Ḣ	
33·83	13·40	8·42	23·01	7·54	2·04	0·96	9·87	=99·07

giving the formula $\dot{R}^3\,\bar{S}i + \ddot{R}\,\bar{S}i + 3\dot{H}$, which is that of Biotite, excepting the water.

The name *Voigtite* is in honor of M. Voigt, director of the mines of Saxe Weimar.

[A mineral of the same composition essentially, from Pressburg, Hungary, has been analyzed by von Hauer. See Wien. Sitzb., xi, 609, 1853, and author's Min., p. 295.]

VÖLKNERITE [p. 134].—Analyses by Rammelsberg of the mineral from Snarum, called also Hydrotalcite (Pogg. xcvii, 296):

	Ö	Äl	Mg	Ḣ	
1.	2·61	37·27	19·25	41·59	= 100·72
2.	6·05	38·18	17·78	[37·99]	= 100·00
3.	7·32	37·30	18·09	[37·38]	= 100 00
4.	7·30	37·04	18·87	37·38	= 100 59

The mineral was in bent or curving lamellæ, which break into fibres. G.=2·091. Rammelsberg regards the carbonic acid as introduced subsequent to the formation of the mineral, and obtains the formula, $\dot{M}g\,\ddot{A}l+4\dot{M}g\,\dot{H}^3$=alumina 19·80, magnesia 38·56, water 41·64=100; or perhaps, $\ddot{A}l\,\dot{H}^3+5\dot{M}g\,\dot{H}^2$=alumina 19·14, magnesia 37·27, water 43·59=100.

WITTICHITE (Kupferwismutherz) [p. 88, and Suppl. I].—Analysis by E. Tobler (Ann. Ch. u. Pharm., xcvi, 207).—(1) part soluble in muriatic acid; (2) part insoluble, ibid.; (3) the whole together:

	S	Bi	Cu	Fe	
1. Soluble part,	16 00	49·12	30·70	1·64	= 97·46
2. Insoluble part,	1·26	0·53	0·86	1·27	= 3·96
3. Whole,	17·26	49·65	31·56	2·91	=101·38

The results agree nearly with those of M. Schneider. The formula may be $2\dot{C}u\,S+\dot{B}i^2\,S^3$; but the sulphur is not sufficient for it. It corresponds better with the analyses to write it, $2\dot{C}u\,S+\dot{B}i^2\,S^2$, or $\dot{C}u\,S+\dot{B}i\,S$; the iron being included with the Ċu.

The composition of this ore from Wittichen is discussed by R. Schneider, in Pogg. Ann., xcvii, 476.

WOLFRAM [p. 351, and Suppl. I, II].—An imperfect crystal of wolfram from the west shore of "Chief's Island," Lake Couchiching, Canada West, has been described by E. J. Chapman (Canadian Jour. [2], i, 308). It was found there in a boulder consisting of gneiss traversed by a vein of coarse granite, containing red orthoclase and some magnetite.

XENOTIME [p. 401, and Suppl. I, II].—E. Zschau has described the associations of Xenotime in the granite of Hitteröe, Norway. in the Neues Jahrb. f. Min. etc., 1855, 513. The minerals occurring with it are allanite, malacone (related to zircon), polycrase, titanic iron; and very rarely gadolinite. The crystals of xenotime sometimes form regular twins with malacone (this Journ., xx, 273), and also have a regularity of somposition with some crystals of orthite (allanite), titanic iron and polycrase. For details, we refer to the paper.

Analysis of the xenotime afforded, $\dot{P}$ 30·74, Yttria 60·25, Ċe 7·98, Si, Fe, *trace*.

ZINCITE [p. 110, and Suppl. II].—Occurs at Schneeberg as a pseudomorph after Blende.—Hartm. Berg. u. Hutt. 1853, in N. Jahrb., 1855, 841.

Additional references.

American localities.—At Canton Mine, Ga., according to Prof. C. U. Shepard (Rep. 1856), chalcopyrite, harrisite, erubescite, hitchcockite, melaconite, galena (containing 30 to 56 oz. silver to the ton), pyromorphite, plumbo-resinite "in thin seams and varnish-like coatings," pyrites, marcasite, mispickel, blende, native copper, automolite, staurotide, kyanite, ilmenite.

Minerals accompanying the Gold of Australia. Quart. J. Geol. Soc., 1854, x, 303.

On the minerals and pseudomorphs of Przibram, by E. Kleszczynski, Jahrb. k. k. geol. Reichs., 1855, 46.

Art. XXIII.—*Correspondence of M. Jerome Nicklès, dated Paris, July*, 1856.

Academy of Sciences.—Death of M. Binet.—The Academy of Sciences has just lost its President for the year 1856—the geometer M. Binet, the pupil, associate, and friend of Laplace, and better acquainted with his ideas and works than any of his cotemporaries. He took an active part in the publication of the Mécanique Céleste, and wrote several memoirs on this subject which will always be consulted with profit. Besides this, he is the author of the Treatise on Eulerian Integrals, and had an intimate knowledge of the works of very many geometers both ancient and modern—knowledge which was always at the service of others, but now is lost to the world. From 1816 to 1830 he was Director of the Polytechnic School, when he was replaced by the distinguished physicist Dulong. He entered the Institute in 1843. He died on the 12th of May last at an advanced age.

Agricultural Universal Exhibition.—It is ten years since this kind of exhibition or fair began, and extended to the different regions of France; and now since the idea of Universal Exhibitions has been introduced, the Agricultural fairs are taking a more liberal range. This exhibition was not as well attended as was hoped, and France was but moderately represented, there being hardly 150 French contributors. The animals admitted were cattle, sheep etc., pigs, and fowls. There was also a horticultural exhibition of unusual beauty, where the Azaleas were combined in great perfection of taste, with Rhododendrons and Calceolarias. The ornamental trees were inferior to those of the Horticultural exhibition of last year.

The department of Pisciculture was a new and interesting feature in this exhibition. There were several basins or reservoirs where the apparatus of Pisciculture of the Collège de France and the products of the establishment founded at Huningue (Haut-Rhin), were exhibited :—including salmon from the Danube and Rhine, the French salmon, trout, etc. etc., comprising various species which have been acclimated without difficulty. Two years since the experiment was begun towards stocking the artificial lake which the city of Paris has made in the Bois de Boulogne. which is supplied with water by means of a great steam engine; this lake, which, has no communication with other waters, is now filled with trout and salmon of the finest kinds.

Another department, adding to the interest of the exhibition, was that of Apiculture—or bees, and the manner of raising and treating them. A part of the exhibition was the same as that in the great Crystal Palace Exhibition.

Fecula of the Horse-chestnut.—Among the products in the Agricultural Exhibition, the different kinds of fecula were of prominent interest, and especially the fecula of the horse-chestnut (Æsculus hippocastanum). The exhibitor of it, M. Callias, has been honored with the silver medal, because of the simple and economical method of extraction which he has brought into use, permitting the fecula to be sold 25 to 30 per cent less than other related products.

This fecula has been many times commended to attention since Bachelier in 1615 brought the tree from Constantinople, (it coming originally from Southern Asia). Parmentier, Baumé and others sought successively to bring it into general use. But the mode of manufacture was not satisfactory, partly because of the presence of a resinous substance which was separated with difficulty, and partly on account of the dark shell of the nut, which it was thought necessary to remove before extracting the fecula.

In the new process, the nuts are grated with the bark on, and treated like the potato with its skin; the material is then washed in water as easily and as economically as the potato, so that the price is not above 20 centimes per kilogram, the cost of cultivation and manufacture being included. 20,000 kilograms of the fecula manufactured this year with the apparatus that is used for the potato have settled the question of its importance.

Astronomy.—Among the changes at the Observatory at Paris, the establishment of the "Annals of the Observatory" is worthy of mention. The object of this periodical is to publish the results of observations of every kind connected with the Observatory, and also of such tables and reductions as are indispensable to give the results an actual scientific value. The completion of the tables to facilitate the discussion of the observations and aid in comparing with theory is making rapid progress. The first volume of the publication is just from the press. It contains the Report of M. Leverrier addressed to the French Government, and following this, a statement of the system of organization now established. There are next, astronomical researches of various kinds, with the principal formulas for the calculation of functions.

This work, whose numerous mathematical formulas render it of difficult execution, goes out almost without a fault from the ably conducted press of Mallet-Bachelier.

View of a part of the surface of the Moon.—M. Secchi, Astronomer at Rome, has sent to the Academy a photographic view of the part of the moon's surface in which stands the crater named *Copernicus*. The scale is about $\frac{1}{665.000}$. The photograph was not taken direct from the moon, but from a design executed with great care on a somewhat larger scale, and having for its base a micrometric triangulation of the principal points of the area. The details were brought out with a lens magnifying 760 to 1000 times: the work, seemingly easy, was attended with great difficulties, on account of the change in the shadows with every hour, the moon's libration and change of distance. To avoid all these difficulties a general sketch was first made under the most favorable light and view for marking out the crater, such as is ordinarily had when the moon is ten days old. After this, the details were separately made out, and then all were combined in their true relations, so as to make the complete sketch. The result thus reached was corrected by several examinations made from the first point of view. A professed draughtsman was occupied with the work during seven consecutive lunations, without counting the time employed previously in practicing preparatory to the work.

As the drawing was intended to represent the great central crater, the area around is not yet filled with all the details that may be introduced.

After completing the design with every possible care, M. Secchi has had copies taken by photography, one of which he has sent to the Academy. The crater or annular mountain has two circuit walls. The outer, which is the lowest, has a diameter of about 48 seconds (one second corresponds to 1·820 meters); the inner, the true border of the crater, has a mean diameter of 38 seconds, and has a peak, somewhat elevated, on its western side. The inner area is 20 seconds across. The interior has a steep escarpment around, and a triple circuit of broken rocks and a great number of large masses piled up at the foot of the escarpment, as if they had fallen from above. There are two great depressions in the north and south borders of the crater; and it is remarkable that in the direction of this line, outside, both north and south, there are some small craters.

After having established the perfect resemblance which exists between the volcanic mountains of the environs of Rome and the lunar mountains,* (comparing with the chart of the Roman territory made by the French officers), M. Secchi adds, "The question whether volcanic action in the moon is actually extinct, can be answered only after there shall have been made a map of the moon's surface for a given period with the utmost accuracy and on a large scale." It is to help onward this project, that he has undertaken the work above described.

Meteorological System of France.—Notwithstanding the enemies of meteorological observations alluded to in a former communication, the system for France is now nearly established. The telegraph reports to the director of the Paris Observatory, M. Leverrier, the observations made at different points over the empire. All the stations are supplied with instruments which have been compared with great care. The instrument which has undergone the most modification is the barometer. The barometer of Fortin, which is the most perfect of all, has not been adopted, because it works well only in the most experienced hands, and the determination of the atmospheric pressure with it is an experiment in physics of great delicacy rather than a direct observation. The instrument used is very simple and gives the pressure of the air at a single reading, the corrections being contained in tables.

Besides the corps of amateur meteorologists, a regular system of observers under administrative direction was required, which should be perpetual and independent of the direct action of those constituting it. This is now realized, the stations being established within the telegraphic bureaus, the assistants in which have had a good education. The number of stations is now 25, and they are situated in the principal basins of France. Each person in charge of a station is required to make three observations a day, but may make more at his pleasure. These observations are registered in a book kept at the station; and at 7 or 8 o'clock in the morning they are reported by the telegraph according to a concerted formula, to the Paris Observatory, where they are recorded on special registers, to be tabulated and published.

* The more thoroughly the volcanic mountains of the moon are studied, the more completely do they sustain the resemblance to the great boiling lava craters like Kilauea of the Hawaian Islands, as pointed out by the writer in an article on the Volcanoes of the Moon, in this Journal, volume ii, 2nd Series, page 335, 1846.—J. D. D.

This system has already worked for a month with entire regularity; and when it shall have been firmly established and have received the sanction of time, M. Leverrier will undertake to extend the system to the neighboring countries. The concurrence of Belgium is promised, and we hope for that of England. Indeed, according to a recent statement at the Observatory, the brother of the Austrian emperor and the Royal Prince of Sweden have promised to contribute all in their power to promote the extension both of the political union and meteorological union of France to Austria and Sweden. But it is well known what such promises are worth.

Inundations.—Since the calamity from floods which has befallen a part of France, many notes and memoirs have been published, both with reference to preventing such catastrophes in the future, and the discovery of the cause. On the latter point there are two opinions, some attributing the rain to hot vapors brought with the winds of Africa, others to the Gulf stream descending very low in the ocean at this time and saturating the air with moisture. Both theories consider the winds as carried against the Alps, there to precipitate their moisture in the state of rain; and it is in accordance with this view that the part of Germany beyond the Alps to the south and east has suffered from drought.

To these meteorological causes, supposing one or both real, we may add the clearing away of forests, the opening of canals, and the means used to facilitate the flow of waters, whence, a drop of water makes a quicker passage to the rivers and thence to the sea, than in the ancient times of uncultivated France. The rivers consequently enlarge suddenly beyond measure and commit ravages from which France periodically suffers. It seems the duty of science then to combat the evils due partly to the progress of science. The organization of a system of meteorological observations is one step towards this end. The inspection of the pluviometer may enable us to foresee by several days the increase of a river, like that at Lyons; and if placed about the heights, the telegraph may announce six days in advance, a flood on the Saone, and enable the people to put the rivers in a state to carry off the excess of water and prevent much of the evil. MM. Pouillet, Regnault and others will hardly deny after this the utility of meteorological observations.

Electricity.—Substitute for the copper wire in the construction of Helices.—The cost of helices of fine wire, and the limit of thickness to which the fine wire can be covered with silk for insulation, are two impediments which M. Bonelli has sought to set aside by very simple means. He takes a band of paper of the height of the helix of an electro-magnet, or of the corresponding part of a galvanometer; this band carries parallel to its edge, metallic lines $a\ a'$, $b\ b'$, etc., passing from one extremity to the other; these lines, placed in the circuit, will give passage to the current, while they are also insulated from one another by the paper which separates them; so that the current will pass uninterruptedly provided the lines of metal are unbroken. The number of these lines which may be put on a band of paper is almost indefinite. Leaving their extremities free, the current may be made to pass, either along the lines united, or in all of them at the same time and in the same direction.

Effects with Ruhmkorff's Apparatus of Induction.—M. Léon Foucault has been engaged for some time in studying the effects of the apparatus of Ruhmkorff. In place of using only a single apparatus, he operates with four, which are united so as to work together by means of a peculiar interruptor,—a mercury interruptor. In the open air, four machines of ordinary dimensions, under the action of ten couples of a Bunsen's large battery, give a spark at a distance of seven centimeters (nearly three inches).

The addition of a condenser in which the armature acts on a surface of 30 to 50 centimeters, renders the spark very bright, and reduces the explosive distance to 18 millimeters. The series of discharges, which follow one another with rapidity, give to the point where the operation is going on, a light like that of an ordinary lamp. Although the brightness from such a source does not appear excessive, it acts on the organs of sight, when observed directly, like the light from the carbon of the galvanic circuit, producing a painful sensation which may continue for hours afterward. The interposition of glass of uranium prevents or diminishes very much this effect, which appears to show that it is due to the very refrangible and in part invisible rays which constitute in large proportion the electric light.

The discharge of the four instruments traverses easily a tube exhausted by an air pump two metres long; a column of light is developed from one end to the other and presents throughout its extent a kind of stratification, such as has been noticed in the interior of the electric egg.

Electric Chronometers.—The ingenious artist, M. Bréguet, son of the skillful mechanician who invented the Bréguet Thermometer, etc., has devoted himself to the construction of chronometers in connection with the Electric Telegraph. During his recent stay at Paris, he has placed a chronometer of great simplicity in a gas lamp. It consists of a dial armed with two needles moved by electricity, which mark the hours and minutes. The whole mechanism consists of three wheels, a pinion, an escapement, and a double rachet, with a means of reversing the current: two wires pass from the lamp to a regulating clock situated in the apartment of M. Bréguet. This inventor proposes to divide Paris into 12 electric districts, and place in each mayoralty a regulator which shall distribute time throughout the district both to the public lamps and private houses.

Gas and Steam Manometer Alarm.—The same artist has made another application of electricity. He has constructed an apparatus for informing the engineer either of gas or steam apparatus, by the stroke of a bell, that the pressure is above or below what is required. It is accomplished in a very simple manner. At the extremities of the arc which the needle of the manometer passes over, there are put two metallic points which limit its movement in either direction; the contact of the needle with these metallic points is made to close a circuit proceeding from a small battery, and this puts the bell in play.

On a Cause of Atmospheric Electrieity.—There exists between the living plant and the soil supporting it an electric current, which always moves in the same direction, that is, the soil is constantly positive, the plant continually negative. This fact, was first observed by M. Becquerel, Sr., and for several years it has been pointed out by him as one of the

causes of atmospheric eleetricity. On repeating the experiments a year since, he was struck with the anomalies presented in operating on the bank of a stream, in the water, and also at a certain distance from the plant, and was thus led to study the effects under these circumstances. These effects are complex and change their direction and intensity with the chemical composition of the water and the soil. In each case the results depend on heterogeneity between the water and the soil; alkaline waters are negative, and acid waters positive; it follows therefore, that sometimes the effects are null, as happens on the waters of a river and along the sandy banks washed by the floods.

Bibliography.—Annales de l'Observatoire de Paris publiées, par U. J. Le Verrier. Vol. I, in large 4to, of 420 pages, with a plate. Paris; Mallet-Bachelier. Price 28 francs.—We have remarked on this work under the head of *Astronomy.*

Œuvres de Fr. Arago.—*Notices Scientifiques.* Vol. II. Paris: Gide et Baudry.—This volume contains, 1st, A historical notice of the Steam Engine; 2d, a Report on Railroads, historical in character, made to the Chamber of Deputies, June 12, 1836; 3d, A Report on the introduction of the Electric Telegraph into France, a report combatted at the time by "les obscurantistes" on the ground that the electric telegraph was a chimera; 4th, a Report on limestone, mortars, hydraulic cements, native and artificial puzzolanas; 5th, A series of remarkable articles under the title of Navigation, treating of different maritime questions. An announcement of the subjects in this volume is sufficient to exhibit its importance.

Le Materiel Agricole, ou Description et Examen des Instruments et des Machines usités en Agriculture, par A. Jourdier.—Paris: Hachette. 1 volume in 12 mo, containing in a concise and elegant form accounts of the principal agricultural operations followed in France.

Notions d'Hygiéne pratique, par le Dr. Isidore Bourdon.—1 volume in 16 mo. of 380 pages, treating fully of the general subject of Hygiene.

Theorie de Logarithmes par Tarnier, Doctor ès Sciences mathematiques.—A pamphlet of 92 pages in 8vo. *Paris:* Hachette.

Elements de Geographie, par Cortambert. 1 volume in 8vo. *Paris:* Hachette.—The author is a Professor of Geography of high reputation with the Parisian public, and his works are in good demand.

Precis d'Histoire Naturelle, par M. Delafosse. 7th edition in 1 volume of 688 pages 12 mo.—This book is in the hands of all the students and is a convenient introduction to the natural sciences. Its author, M. Delafosse, is moreover Professor of Mineralogy in the Faculty of Sciences of Paris, where he has given instruction for nearly twenty years.

Les applications nouvelles de la Science à l'Industrie et aux Arts, en 1855, *par* L. Figuier, M.D., Doctor ès Science, Redacteur du Bulletin Scientifique de la presse. 1 volume of 788 pages in 12 mo.—This small volume is one of the results of the "Universal Exposition" at Paris. It has been well prepared, and has in view an exhibition of the principal applications of science relating to the Steam engine, Steam vessels, Electromotors, Clocks, Electricity and Railroads, Photography, Photographic engraving, Galvanoplasty, Stearic candles, Electric illumination, Heating by gas, Aluminium, etc. etc.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Some Experiments in Electro-physiology ;* by Prof. MATTEUCCI, in a letter to Dr Faraday, dated May 1, 1856, (Phil. Mag. [4], xi, 461.)—I think I have already told you that for some time past I have been making experiments in electro-physiology. Allow me now to communicate to you the results of my work.

I have lately succeeded in demonstrating and measuring the phenomenon which I have called *muscular respiration.* This respiration, which consists in the absorption of oxygen and the exhalation of carbonic acid and azote by living muscles, and of which I have determined the principal conditions and intensity compared with that of the general respiration of an animal, has been studied particularly on muscles in contraction. I have proved that this respiration *increases considerably* in the act of contraction, and have measured this increase.

A muscle which contracts, absorbs, while in contraction, a much greater quantity of oxygen, and exhales a much greater quantity of carbonic acid and azote, than does the same muscle in a state of repose. A part of the carbonic acid exhales in the air, the muscle imbibes the other part, which puts a stop to successive respiration and produces *asphyxy of the muscle.* Thus a muscle soon ceases to contract under the influence of an electro-magnetic machine when it is enclosed in a small space of air; this cessation takes place after a longer interval of time if the muscle is in the open air, and much more slowly still if there be a solution of potash at the bottom of the recipient in which the muscle is suspended. Muscles which have been kept long in vacuum or in hydrogen are nevertheless capable, though in a less degree, of exhaling carbonic acid while in contraction; this proves clearly that the oxygen which furnishes the carbonic acid exists in the muscle in a state of combination. According to the theories of Joule, Thomson, &c., the chemical action which is transformed, or which gives rise to heat, is also represented by a certain quantity of *vis viva*, or by an equivalent of mechanical work. I have therefore been able to measure the *theoretical work* due to the oxygen consumed, taking the numbers which I had found for muscular respiration during contraction, and in consequence the quantity of heat developed by this chemical action, and finally this *theoretical work* according to the dynamical equivalent of heat. I have compared this number with that which expresses the *real work* which is obtained by measuring the weight which a muscle in contraction can raise to a certain height, and the number of contractions which a muscle can perform in a given time. It results from this comparison, that the first number is somewhat greater than the second, and the heat developed by contraction ought to be admitted among the causes of this slight difference: these two numbers are therefore sufficiently in accordance with each other.

I have completed these researches by some new studies on *induced contraction*, that is to say, on the phenomenon of the irritation of a nerve in contact with a muscle in contraction. A great number of experiments lately

made on the discharge of the torpedo, and on the analogy between this discharge and muscular contraction, have led me to establish the existence of an electrical discharge in the act of muscular contraction. The general conclusion to be drawn from these researches is, therefore, that the chemical action which accompanies muscular contraction develops in living bodies, as in the pile or in a steam-engine, heat, electricity, and *vis viva*, according to the same mechanical laws.

Allow me to describe to you briefly the only one of these experiments which can be repeated in a lecture, and which proves the principal fact of these researches, although it is limited to prove that muscles in contraction develop a greater quantity of carbonic acid than those in repose. Take two wide-mouthed glass phials of equal size, 100 or 120 cub. centims.; pour 10 cub. centims. of lime-water (eau de chaux) into each of these phials. Prepare ten frogs in the manner of *Galvani*, that is, reducing them to a piece of spinal marrow, thighs and legs without the claws, which are cut in order to avoid contact with the liquid in the phials. The cork of one of these phials is provided with five hooks, either of copper or iron, on which five of the prepared frogs are fixed. Through the cork of the other phial are passed two iron wires, bent horizontally in the interior of the phial; the other five frogs are fixed by the spinal marrow to these wires. This preparation must be accomplished as rapidly as possible, and both the phials be ready at the same instant, and great care taken to avoid the contact of the frogs with the sides of the phials or the liquid. When all is in readiness, with a pile of two or three elements of Grove, and with an electro-magnetic machine such as is employed for medical purposes, the five frogs suspended on the two iron wires are made to contract. After the lapse of five or six minutes, during which time the passage of the current has been interrupted at intervals in order to keep up the force of the contractions, agitate gently the liquid, withdraw the frogs, close rapidly the phials, and agitate the liquid again. You will then see that the lime-water contained in the phial in which the frogs were contracted is much whiter and more turbid than the same liquid contained in the other phial in which the frogs were left in repose. It is almost superfluous to add, that I made the complete analysis of the air in contact with the frogs according to the methods generally employed.

2. *Selenium.*—Crystalline form according to Mitscherlich (J. f. pr. Chem. lxvi, 257) is monoclinic. $I : I = 64° 56'$, $i2 : i2$ (planes beveling front edge) $= 103° 40'$, C (or $O : ii$) $= 104° 6'$, $O : \frac{1}{2}\dot{i}$ (clinodome) $= 142° 54'$, $O : 1 = 124° 48'$, $O : -1 = 112° 36'$.

3. *Iodine.*—Crystalline form (Mitscherlich, J. f. pr. Chem. lxvi, 265) trimetric; $I : I = 112° 48'$, $O : 1 = 112° 4'$, $O : 1\breve{i} = 126° 13\frac{1}{2}'$, $O : 1\bar{i} = 115° 57'$, $1\breve{i} : 1\breve{i}$ (top) $= 72° 27'$, $1\bar{i} : 1\bar{i}$ (top) $= 51° 54'$.

II. MINERALOGY AND GEOLOGY.

1. *Meteoric Iron of Thuringia.*—Description and analysis by W. Eberhard, (Ann. Ch. u. Pharm., xcvi, 286.)—Found on the 18th of October, 1854, near Tabarz, near the foot of the Inselbergs, not far from Gotha, and said to be still hot when picked up, though this is doubted. The mass is a small one, and is oxydized over the surface. It resembles much

that of Bohumilitz. In the outer crust, there are pieces of schreibersite and protosulphuret of iron. The Widmannstädtian figures are large. G.=7·737. Composition of this and the Bohumilitz irons:

	Fe	Ni	Co	Ph	Schreibersite
1.	92·757	5·693	0·791	0·862	0·277 = 100·380
2. Bohumilitz,	92·173	5·667	0·235	——	1·625 = 100, Berzelius.

2. *Meteoric Iron of Cape of Good Hope.*—Analyses by Uricoechea and Böcking (Ann. Ch. u. Pharm., xcvi, 246):—

	Fe	Ni	Co	Ph	Cu, Zn, S		
1. Uricoechea,	81·20	15·09	2·56	0·09	*trace*	Schreibersite,	0·95=99·89
2. Böcking,	81·30	15·23	2·01	0·88	*trace*	"	0·88=99·50

3. *Meteoric Stone of Mezö-Madaras in Siebenburg.*—Analysis by F. Wöhler (Ann. Ch. u. Pharm., xcvi, 251):—Native iron 18·10, nickel 1·45, cobalt 0·05, graphite 0·25, magnesia 23·83, Ḟe 4·61, Ṁn 0·28, Ä̇l 3·15, Ċa 1·80, Ṅa 2·34, K̇ 0·50, sulphur, phosphorus, and oxyd of chrome undetermined, silica 43·64=100. Separating 19·6 p. c. of nickeliferous iron, the rest was subjected to muriatic acid. The insoluble part and soluble part gave:

		Si	Ä̇l	Ṁg	Ḟe	Ċa	Ṅa	K̇	Graphite
1. Insoluble,		18·502	0·564	4·660	4·643	0·929	0·585	0·347	0·250=30·480
	In 100 parts,	60·70	1·85	15·29	15·25	3·05	1·91	1·13	0 82 =100
2. Soluble,		26·336	2·586	19·170	——	0·870	1·755	0·153	=50·920
	In 100 parts,	51·84	5·08	37·64	——	1·70	3·44	0·30	=100

The author concludes that the stone consists of olivine, augite, labradorite, with nickeliferous iron, sulphuret of iron, graphite, and a small proportion of chromic iron.

The meteorite fell on the 4th of September, 1852.

4. *On the Volcanoes of Southern Italy;* by M. C. St. Claire Deville (L'Institut, No. 1173).—M. Deville has prepared a report on his two journeys to the volcanic region of southern Italy. In connection with MM. Leblanc and Lewy, he has analyzed the gases and specimens collected by him, and the following are some of the results.

The gas of the fumaroles which he calls *dry fumaroles*, and of those that usually afford alkaline anhydrous chlorids with some sulphates, is pure air deprived of a very small proportion of oxygen. The gas analyzed was collected at Vesuvius in May, June, September and October, 1855.

The gas collected in September, 1855, from one of the fumaroles of the crater over the small central plain, from which vapor of water with sulphur and sulphuretted hydrogen were issuing, afforded, one specimen, 3·51 p. c. of carbonic acid; another 9·26 p. c. The rest was pure atmospheric air, or air deprived of its oxygen.

Two specimens of gas collected on the 5th and 22nd of October from the Lake Naftia in Sicily gave for the first, Oxygen 17·36, nitrogen 82·64; the second, oxygen 15·77, nitrogen 79·23, carbonic acid 5·00, showing the variations in the gaseous emanations.

The white mineral of the Vesuvian lava of recent eruptions is probably leucite, it having the specific gravity 2·48, and the oxygen ratio for the bases and silica 3 : 8·2. But it differs from the leucite of Somma in containing more potash, the oxygen ratio of the soda and potash being 1 : 2·09 in this mineral from the lava of 1855, and in the Somma (Fossa Grande) leucite 1 : 821. Moreover in the crystals from the lava of 1847, as he learns from M. Damour, this ratio is 1 : 1·67.

5. *On the Isthmus of Suez;* by M. RENAUD, (L'Institut, No. 1173)—The greatest elevation of the isthmus of Suez above the Mediterranean is 16 meters, and this extends along only for a few miles. Between this higher part and the Gulf of Suez on the Red Sea, there are two depressions, one, the basin of the Bitter Waters, dry; the other, called Lake Timsah, occupied with water which when flooded flows towards the Nile along the Wady Toumilah. The height of land between these two basins is 11 meters above low tide in the Mediterranean; and the height between Lake Timsah and the Gulf of Peluse is but 9 meters. The distance across the isthmus in a straight line from the Gulf of Suez to the Gulf of Peluse is 113 kilometers (70 miles). It is a sandy and nearly barren region, to the north more gravelly. The southern half is completely sterile; the northern produces the vegetation peculiar to the deserts, on which the camels feed. On the borders of Lake Tismah, over the dry parts of its bed, and on the channel leading to Wady Toumilah, tamarinds grow in abundance. The sands of the isthmus are fixed, that is, not movable, and there are therefore no dunes. In some places there are minute disseminated crystals of gypsum, and also deposits of the same 6 to 15 inches thick; in other places concretions of carbonate of lime occur over the surface of the sand, and on some sand hills, one or two beds of limestone having the appearance of quartz.

In the north part of the basin where it was deepest, there is a deposit of salt 7½ meters thick, struck in sounding No. 10; and in sounding No. 9, salt was found covered by a bed of gypsum in fine needle crystallizations.

In the region between the Bitter lake basin and the Red Sea, there were encountered below the sand, compact clay, sandy clay, sand and gravel, laminated clay, &c. In the second sounding, a band of calcareous rock was found resting on one of sand. A marly clay was found in a third sounding. But in general, the clays hardly effervesced at all with acids. Beyond the Bitter lake basin there were only sands, excepting in sounding 19, a band of marl.

In the basin of the Bitter lake, shells occur like those of the Red Sea, among which a species of Mactra is very common. It is probable that these shells have not lived in the waters since the basin was shut off from the tides of the Red Sea, since the hot climate, after such a separation, would soon concentrate the waters by evaporation and so destroy all living species. It is true that in the time of Strabo and Herodotus the basin contained water: but it was fresh water which was brought there by the canal joining the Nile and Red Sea. It is a controverted question whether the lakes were yet a part of the Red Sea when the Jews under Moses left Egypt. The affirmative accords best with the sacred text; but then, the elevation of Suez must have taken place since that event.

The banks of the sea as well as the soil of the isthmus show no evidence of marked change since the most remote periods. The sand and shells of the present beach look very different from those of the interior, and contain many shells not found in the latter. These seashore sands have a width nowhere exceeding 100 meters. There is still more evidence on the Gulf of Peluse that there has been no change of level since the earliest historical period.

6. *On the Mines of Mineral Coal in Peru;* by M. E. de Rivero.*—The works published on Peru scarcely make any mention of the Peruvian Coal Mines. I propose to supply this deficiency of information, at least in part, by some account of the beds which I have seen in the Cordillera, some of which I have myself discovered.

Along the Coast district, although coal occurs in some places, it has not been found in mines of workable value. This remark applies to the island of San Lorenzo near Callao, and the district of Tumbès. Still, we believe that a careful survey may yet bring to light beds of value which will well repay the expense of exploration, since coal is so essential to industry, and especially to the Peruvian steamers, which are now compelled to import it from England at great expense.

The discovery of the coal mines of Peru dates from the introduction of steam engines which were established by the Company of Abadia in 1816 in the *Cerro de Pasco*, department of Junin. The first bed was discovered by Hudille in the hill called *Rancas*, two leagues from Cerro. At first it was not known what to do with the coal; for charcoal and peat were employed in their kitchens and forges, and for the distillation of the silver amalgam. But afterwards, on its coming into use for engines, it was gradually introduced for domestic purposes, the district affording little wood; and now there is only a single house in which a fire-place is constructed for burning charcoal. The climate of the *Cerro del Pasco*, a place situated 4,352 meters above the sea, is consequently more supportable.

The coal beds of Rancas have a north and south direction and a dip to the west. They overlie shales and sandstones and are covered by the same rocks. There are many flexures and faults, as in the coal regions of Belgium and elsewhere. The principal bed is quite large; the coal is excellent, giving much flame and little residue, and serving well in forges; its structure is not as schistose as usual.

Other beds have since been discovered. Two leagues from Cerro, in the peak of *Colquyilca*, there are three coal beds of moderate thickness and good quality. At the Quebrada of *Fulluranca*, on the road from Huanuco, in the peaks of Puelles, Anaspuquio and Siricancha, near the property belonging to Don Gaspar Sola, there are considerable beds which are used for heating houses and also for the *pella* of silver. They occur between sandstone and a limestone which contains galena. Not far distant, I have found a greenish fluor associated with the galena.

In the direction of the silver mine of Vinchos, (a mine worked extensively and with great profit), on the ascent of the peak of *Pargas*, at a place called Curaopuero, there is a coal bed 15 varas (41·7 feet) thick. The coal is but little bituminous, and it burns easily, leaving a white slaty residue. The mine belongs to MM. Sanchez and Don Ricardo Joch.

Four leagues from this point, to the right, stands the peak of Pictichaca (a word signifying *bridge.*) at the foot of which there are the lakes of Geguey and Boliche. It contains the silver mines of *Rosario*, belonging to the lands of Jarria, and other mines which it is said have been explored by a Portuguese company.

* Ann. des Mines, [5], vii, 1855, p. 459.

On the descent of the Quebrada de Vinchos, in the peak of *Churca*, there is a bed of coal which I discovered. I believe it to be of good quality, although of little thickness. Near the village of *Pallanchaca*, there is an important bed which is yet to be explored.

The extensive silver mine of *Huallanca* has near it beds of mineral coal, 4 to 5 varas thick, and of excellent quality; and it is probable that manufactories and founderies will consequently be established. The height of Huallanca above the sea level is 3,527 meters. Near the quicksilver mine of *Chonta*, at a height of 4,465 meters, there are beds of coal, hitherto explored only for heating. They rest on sandstone and alternate with conglomerate and iron pyrites.

Coal is also found in the profound Quebrada of *Queropalca*, a region very rich in metals, especially lead; also in *Chavin de Guanta*, celebrated for its famous castles of the ancient Incas. Near the mine of Oyon, Province of Cajatambo, several beds of superior quality have been explored, covering many leagues. The old mine of antimonial sulphuret of silver, lying upon magnesian carbonate of lime, and whose exploration has lately been undertaken by an American (U. S.) company, has not responded to their expectations. The village of Oyon is 3,621 meters above the sea level.

In the hill of *La Vinda*, on the road from Obragillo to Cerro de Pasco, at an elevation of 4,613 meters, I have observed coal in horizontal beds between sandstone and shale, containing fossil shells which were too imperfect to make out the species. There is coal also in the villages of Marcapopacocha, Alpamarca, Pallanea, etc.

Twelve leagues from Cerro, there is the coal bed of *Cullutago*, extending on both sides of the Quebrada of the village of Huallay enclosed by the elevations of Andacancha and Anascacha; the bases of these elevations are of sandstone, while the summits consist of white trachyte containing bits of greyish perlite and white transparent quartz. Before arriving at Huallay, ores of silver and mineral coal are met with on the road. Coal also occurs in the peak of Chicacha, which contains also mines of silver. The base of the mountain is remarkable for a saliferous marl, the source of several salt springs or streams.

In the peak of *Aranvaldpan*, there are several other mines of good coal, which were opened by the Company of Abadia for the smelting of argentiferous galena. There is another near the small lake of Pichac, explored by M. Alexander Verastegui, but of inferior quality. Near Huaypacha, there is a bed of lignite. At Chapalca, near Puipuy, coal exists in a bed of considerable extent; also of superior quality and extent near Huayay. Coal is also said to occur in the road from Farma to Jauja, and at the Quicksilver mine of Huancavelica.

Some years since, coal beds were discovered at the Quebrada of Murco, in the department of Arequipa. This Quebrada, the commencement of the Valley of Siguas, takes its origin at the foot of the high and majestic Nevado de Sallaly, whose summit is covered with perpetual snow and will never be scaled by man. I think that the height is greater than that of the volcano of Arequipa, which is 6,600 meters. All travelers who pass the foot towards Lampa or Puno, suffer from extreme cold and dizziness from the rarity of the atmosphere, causes which in some seasons

have occasioned the death of the animals themselves. The Quebrada of Murco trends from the northwest to the southeast, and consists, as far as in view, of sandstone and black schist. Fifty *ranchos* (huts of straw or stone) are occupied by the natives in charge of their herds, and this is all the population. They cultivate Indian corn, poor peaches, together with the Chilca (Eupatoria resinosa) a shrub that grows abundantly and which dug into the ground makes an excellent fertilizer. At four to six *cuadras* from these *ranchos*, on the banks of a stream which is impassable in the rainy season, there are some beds of coal in the slate, which dip to the north, the strike east-southeast and west-northwest. They are explored at the surface for a breadth of some varas, and are associated with ironstone and pyrites. I have observed other beds near, which appear to be of better quality. One explored under the direction of M. Uria, has a breadth of more than a yard, and the coal has been tried in the Pacific steamers. It is carried to Arequipa, 15 to 16 leagues, for the forges there in operation. I believe that it will soon be employed in the valleys of Siguas and Vitor for the distillation of wine.

In the valley of Mages, near the property of Querulpa, I have found in a limestone a small and nearly horizontal bed of coal which I have left to Manuel Reyes to explore. In the Quebrada of the warm springs of Yura, nine leagues north of Arequipa, I found, in 1827, coal in a blackish schist like that of Compuerta, on the road from that village to Puno. There are said to be other beds at Esquino, on the route from Moquega, and at Morro on the way from Sama. From the nature of the beds, coal may yet be found near Arica. There are still other places in La Costa or the Coast Region, where it may be found.

Thus Peru is not destitute of beds of mineral coal. But owing to the great distances and the want of roads, the industrial establishments of the coast are still compelled to provide themselves from foreign dealers at great expense, paying 20 to 25 dollars a ton.

7. *Waters of Lake Ooroomiah;* by Henry Witt, (Phil. Mag. [4], xi, 257)—The waters of Lake Ooroomiah examined, were collected by Mr. W. K. Loftus. The lake, he says, is "about 82 miles in length and 24 wide, its height being 4100 feet above the level of the sea. The water is of a deep azure color, but there is something exceedingly unnatural in its heavy stillness and want of life. Small fragments of Fuci, saturated with salt, and thrown ashore, form a ridge at the margin of the lake, and emit such a noxious effluvium under a hot sun as to produce nausea at the stomach. The sulphuretted hydrogen generated from the lake itself without doubt adds to this sensation. The water is intensely salt, and evaporates so rapidly, that a man, who swam in to bring me a bottle of the water for analysis, on coming out was covered with particles of salt, and looked as white and ludicrous as though he had been thrown into a flour tub."

The sample was taken from the lake at Guverjin Kalah, on the north-western shore, on the 14th of August, 1852, the temperature of the water at the time being 78° F. at 11 A. M.

As I received it (the cork having been well secured by a coating of wax), the water still retained a strong smell of sulphuretted hydrogen, and was moreover supersaturated with carbonic acid, which it evolved on being

shaken or gently heated. It was evidently a very strong brine, for it tasted intensely of common salt, and left on every place on which a drop evaporated spontaneously a large quantity of saline residue. On leaving a portion of it for a few hours in a warm laboratory in an open dish, large cubical crystals, exhibiting the peculiar step-like cavernous structure of common salt, separated in abundance.

Its specific gravity was 1·18812, and on evaporation it gave a total quantity of solid residue amounting to 21856·5 *grains in the gallon.*

In the imperial gallon (of 70,000 grains) there were present 10470·439 grains of chlorine, corresponding to 17254·27 grains of common salt; the remainder of the saline matter, amounting to 4602·23 grains, consisted chiefly of alkaline carbonates, but also contained small quantities of the sulphates and carbonates of lime and magnesia; the smallnes of the quantity of water in my possession prevented the possibility of determining their actual amount.

To indicate the position of the Lake of Ooroomiah among natural brines, I append a table showing the specific gravities, total quantities of solid residue, and of common salt, in the gallon of several of the mineral springs of Harrogate (analysed by my friend Mr. Northcote and myself

Name of water.	Specific gravity.	Total residue in the gallon, in grains.	Common salt in the gallon in grains.	Authority.
Seas :—				
The Mediterranean....	....	2870	....	Pfaff, 1839.*
do.	....	2851	1905	Laurens, 1839.†
do.	1·0287	....	....	A. H. and R. Schlagintweit, 1854.‡
English Channel.....	....	2660	....	Pfaff.
do.	....	2468	1890	Schweitzer, 1839.†
German Ocean at the Frith of Forth....	....	2174	....	Pfaff.
Baltic Sea at Kiel in Holstein	....	1400	....	do.
Atlantic.....	1·027	....	....	A. H. and R. Schlagintweit.
Red Sea	1·0315	....	....	do.
Brines :—				
Harrogate Springs.				
1. Old Sulphur well...	1·01113	1096	866	Hofmann, 1854.§
2. Montpelier strong sulphur well...	1·01045	966	803	do.
3. Hospital strong sulphur well...	1·00515	437	369	do.
Dead Seas	1·211	17220	....	Marcet.‖
Droitwitch brine	1·1893	20157	19392	A. B. Northcote, 1855.¶
Stoke brine	1·2044	22256	21492	do.
Lake of Ooroomiah	1·11812	21856	17254	H. M. Witt, 1856.

* Pfaff, Schwartze's *Allgemeine und specielle Heilquellenlehre.* Leipsic, 1839.

† Laurens and Schweitzer, Phil. Mag., [3], vol. xv, p. 51.

‡ Phil. Mag. for 1855, vol. ix, p. 396, "On the Temperature and Density of the Seas between Southampton and Bombay."

§ Hofmann, Quart. Journ. of Chem. Soc., vol. vii, p. 161.

‖ Marcet, Nicholson's Journal, vol. xx, p. 25.

¶ Northcote, Phil. Mag. Jan. 1855.

for, and under the direction of, Dr. Hofmann), as well as of other brine-springs, and the waters of certain seas.

The extreme saltness of this and the neighboring lakes would appear to arise from the separation, at some remote period, of these masses of salt water from the main ocean, together with the great Caspian and Aral lakes; and the continued evaporation by constantly diminishing their volume (as has been proved by observations on the spot) has caused them ultimately to become, as they are, perfectly saturated brines: and Mr. Loftus states that there are other lakes in the neighborhood which have completely dried up. leaving nothing but a great bed of salt.

8. *On the Koh-i-Noor Diamond*, (from the Proceedings of the Ashmolean Society, Feb. 12, 1855).—The Secretary (M. Maskelyne) made a communication on the history of the Koh-i-Noor diamond. After recounting the fabulous and traditionary accounts of it existing still in India, whereby its antiqnity was carried back to the Indian hero Bikramaditya, 56 B. C., and even to the fabled age of Krishna, he drew attention to the account of a large diamond described by Baber, the founder of the Mogul dynasty, in his memoirs, the authenticity of which is unquestionable. He mentions it as a part of the spoil taken by his son, Hûmayûn at Agra, after that battle of Paniput, in which Ibrahim Lodi fell, and with him his ally or tributary the Rajah of Gwalior Bikramajit, custodian of the fortress of Agra. It is reported by Baber to have come into the Delhi treasury from the conquest of Malwa by Ala-ed-deen in 1304.

Baber gives its weight as about 8 mishkâls. In another passage he estimates the mishkâl at 40 ratis, which would make its weight 320 ratis. It is singular that Tavernier describes a diamond which he saw in 1665 among the crown jewels of Aurungzebe, as having exactly this weight, or rather as weighing 319½ ratis. To this diamond, however, he assigns another history, making it identical with a huge diamond said to have been given by Meer Jumla, the King of Golconda's Minister, to purchase the good will of Shah Jehaun, preparatory to his exchanging into his service from one in which it was no longer safe for him to remain. This diamond is alluded to by Bernier also, and seems to have had a real existence, though Tavernier's account of its cutting admits to its having been greatly injured, and possibly leads to the inference that it was ruined in the process. In order to make out which of these two historic diamonds is the Koh-i-noor, Mr. Maskelyne went minutely into Tavernier's description, comparing it with his drawing of it, and with his own language in another place. He showed that Tavernier's accounts of the exhibition to him of the jewels of Aurungzebe differed slightly in themselves, and entirely from his drawing of the diamond; but that the former, on the whole, represented with singular fidelity the original appearance of the diamond now in England, supposing it to be mounted in such a manner as to conceal the lower part of it. It seemed probable, however, from another reason, that the diamond Tavernier saw was not the one he imagined it to be, and of which he had doubtless heard descriptions in the mines of Golconda, but the diamond of Baber. Aurungzebe held his father a state prisoner. Shah Jehaun had been asked by his unfilial conqueror to give him some of the splendid jewels which he retained in his captivity; at first, indignantly refusing, Shah Jehaun threatened to de-

stroy them; but afterwards,—"some time before his death"—he surrendered some of them, but kept many. After his death these were given to Aurungzebe by his sister Jehanira. Would Shah Jehaun have given to Aurungzebe or would he have retained a diamond, (supposing it to have escaped destruction, in the cutting,) which had been the prize of his interference with the affairs of Golconda, and had been perhaps the ultimate cause of his son's triumph over him? Far more probably would he have given him the true Mogul diamond, the proudest jewel of the conquests of his great ancestor, and that to which Aurungzebe stood indefeasibly, though by fratricide truly Indian, the unnatural heir. Tavernier saw the jewels of Aurungzebe on Nov. 3, 1665. Shah Jehaun died in February, 1666. Tavernier saw but one very large diamond. The dates agree with the supposition; and there are not likely to have been two diamonds, one of 320, the other of 319½ ratis.

It is very difficult to determine the weight of the rati. It is variable in place and time, and, in many places is a conventional weight. The rati is the *Abris precatorius* or *rutka*, a little red seed with a black tip to it, which was, like our barleycorn, a standard of weight over all India, which however varied from about 1·86 of a grain up to 2·25 grains; the coins of Akbar leading to the inference of its weight being nearly 1·9375 of a grain. It is obviously useless to multiply so small a number by 120, for we could expect no accurate result, owing to the exaggeration of the error arising from the multiplication of even the smallest mistake in the true weight of the rati in Baber's or Tavernier's time. But the eight mishkâls of Baber afford a far more hopeful estimate of the weight of the diamond. This is a Persian weight, and seems to be and to have been far less liable to fluctuation or variety in value at different times or places. The Persian mishkâl, or half-dirhem, weighs 74-5 grains troy, and eight of these equal 596 grains, or 187·58 carats.* The Koh-i-Noor in the Exhibition of 1851 weighed 186 carats. This would require a weight of 1·848 grains for the rati, a number nearly approximating to that given by the coins of Akbar.

Accepting then the conclusion, that the great diamond which was the spoil of Ala ed Deen in 1306, and had probably been for ages the crown jewel of the independent Rajahs of Malwa, passed to the Mogul conqueror of the Pathan sovereigns, and was so inherited by the Mogul emperors, and was seen in their possession by Tavernier in the reign of Aurungzebe; Mr. Maskelyne went on to trace its subsequent history.

It remained at Delhi, until another, the fiercest and the last of the great inroads of Western Tartar peoples, broke over the hills of Affghanistan, and flooded the plains of North Western India.

The history of Thamas Kouli Khan, Nadir Shah, is sufficiently near to the present time to fall almost within the field of European contest in India. This conqueror from the west gave back the prostrate empire of India to his Tartar "kinsman" on the throne of Delhi, and exchanged turbans with him,—so says tradition,—in sign of eternal amity. The proud diamond of the Moguls was in the cap of the vassal, and was saluted by the title of Koh-i-Noor, "Mound of Light" by his suzerain. It went back

* The carat = 3·17 grains Troy weight.

with all the fabulous wealth the Persian host bore with them to Khorassan. From Nadir Shah it passed into the hands of his powerless representative Shah Rokh; but it was not one of the jewels afterwards extorted from him by such frightful torture. The history of Ahmed Shah, founder of the short-lived Douranee empire, is that of many other historic names. The realms conquered by Nadir fell asunder at his death; and the Affghan, captain of his horse and lord of his treasure, secured for himself the kingdoms surrounding his native passes, and erected them into an empire, which extended from Moultan to Herat, from Peshawur to Candahar. From his Affghan eyrie he descended to aid his old master's son in the hour of his adversity, sealed an alliance with him, and bore back the great diamond whose beauties "its blind owner could no longer see," and which became once more an equivocal symbol of friendship between sovereigns of whom the recipient of the diamond was the stronger. From Ahmed Shah it descended with the throne to his sons. The wild romance of Shah Soujah's life was in no small degree linked with this gem. Long hidden in the wall of a fortress that had been Shah Zemaun's prison, it shone on the breast of Shah Soujah when the English embassy visited Peshawur. Mahmoud reasserted with success the claim of might to the empire of his brother, and Shah Soujah became an exile. But his companion in that exile was the Koh-i-Noor, and, hunted from Peshawur to Cashmere, and decoyed from Cashmere to Lahore, Shah Soujah became in semblance the guest, in reality the prisoner, of Runjeet the Lion. He disgorged the prize for the sake of which the lord of the five rivers had inveigled him to his lair: and the ex-king of Caubul and Douranee prince escaped the gripe of his savage tyrant only to enter on adventures, the story of which might for incident and hardship challenge the pages of romance. The Koh-i-Noor had again been true to its tradition. It had passed from the weak to the strong under the semblance of righteousness. "At what do you estimate its value?" said Runjeet to his victim. "At good luck," replied Shah Soujah, "for it hath ever been the property of him that hath conquered his enemies." The successors of Runjeet Sing inherited the Koh-i-Noor, and when the Sikh power fell before the arms of England, which it had challenged, the talisman of Indian sway passed from the treasury of Lahore to the jewel-chamber of Windsor; and reposes once again, as the proudest jewel in the tiara of Indian empire. But it is no more the Mountain of Light. It is no longer the finest diamond known in the world: it has been recut, as well perhaps as it was possible to recut it*, and is now a brilliant, weighing but 103 carats. Although no more the 8 mishkâls of Diamond that Baber valued at half the rent-roll of a world, it is the identical gem that has contributed its light to the glories of every dynasty that has dazzled the East by the supremacy of its arms for perhaps a thousand years.

9. *On the origin of Greensand, and its formation in the Oceans of the present epoch;* by Prof. J. W. Bailey, (Proc. Bost. Soc. Nat. Hist., vol. v, p. 364.)—As an introduction to the subject of this paper, it is proper to refer to various observations which have been made of facts intimately

* The artistic part of the work, performed by Dutch artists under the superintendance of Messrs. Gerrard, the Queen's Jeweller, was admirably executed.

related to those which I wish to present. That the calcareous shells of the Polythalamia are sometimes replaced by silica, appears to have been first noticed by Ehrenberg, who, in a note translated by Mr. Weaver, and published in the L., E. and D. Philosophical Journal for 1841, (vol. xviii, p. 397,) says :—

"I may here remark that my continued researches on the Polythalamia of the Chalk, have convinced me that very frequently in the earthy coating of flints, which is partly calcareous and partly siliceous, the original calcareous shelled animal forms have exchanged their lime for silex without undergoing any alteration in figure, so that while some are readily dissolved by an acid, others remain insoluble; but in chalk itself, all similar forms are immediately dissolved."

The first notice of *casts* of the cells and soft parts of the Polythalamia was published by myself in the American Journal of Science for 1845, vol. xlviii, where I stated as follows :—

"The specimens from Fort Washington presented me with what I believe have never been before noticed, viz: distinct *casts* of Polythalamia. That these minute and perishable shells should, when destroyed by chemical changes, ever leave behind them indestructible memorials of their existence was scarcely to be expected, yet these casts of Polythalamia are abundant and easily to be recognized in some of the Eocene Marls from Fort Washington." This notice was accompanied by figures of well-defined casts of Polythalamia (l. c. pl. iv, fig. 30, 31).

Dr. Mantell also noticed the occurrence of casts of Polythalamia and their soft parts, preserved in flint and chalk, and communicated an account of them to the Royal Society of London, in May, 1846. In this paper he speaks of the chambers of Polythalamia as being frequently filled with chalk, flint, and *silicate of iron.* (Phil. Trans., 1846, p. 466.) To Ehrenberg, however, appears to be due the credit of first distinctly announcing the connection between the Polythalamia and the formation of Greensand, thus throwing the first light upon the origin of a substance which has long been a puzzle to geologists. In a notice given by this distinguished observer upon the nature of the matrix of the bones of the Zeuglodon from Alabama, (see Monatsbericht, Berlin, February, 1855,) he says :—

"That Greensand, in all the numerous relations in which I have as yet examined it, has been recognized as due to the filling up of organic cells, as a formation of stony casts (Steinkernbildung) mostly of Polythalamia, was stated in July of the preceding year." He then refers to the Nummulite Limestone of Traunstein in Bavaria, as rich in green opal-like casts (Opalsteinkernen) of well-preserved Polythalamian forms, and mentions them as also occurring, but more rarely, in the Glauconite Limestones of France. He then proceeds to give an account of his detection of similar casts in the limestone adhering to the bones of the Zeuglodon from Alabama, and states that this limestone abounds in well-preserved brown, green, and whitish stony casts of recognizable Polythalamia. This limestone is yellowish, and under a lens appears spotted with green. These green spots are the Greensand casts of Polythalamia, and they often form as much as one-third of the mass. By solution in dilute chlorohydric acid, the greensand grains are left, mixed with quartzose sand, and

with a light yellowish mud. The latter is easily removed by washing and decantation. The casts thus obtained are so perfect that not only the genus, but often the species of the Polythalamia, can be recognized. Mingled with these are frequently found spiral or corkscrew-like bodies, which Ehrenberg considers as casts of the shells of young mollusks.

With reference to the perfection of these casts of the Polythalamia, and the light they throw upon the structure of these minute animals, Ehrenberg remarks :—

"The formation of the Greensand consists in a gradual filling up of the interior space of the minute bodies with a green-colored, opal-like mass, which forms therein as a cast. It is a peculiar species of natural injection, and is often so perfect, that not only the large and coarse cells, but also the very finest canals of the cell walls, and all their connecting tubes are thus petrified, and separately exhibited. By no artificial method can such fine and perfect injections be obtained."

Having repeated the experiments of Ehrenberg upon the Zeuglodon limestone, I can confirm his statements in every particular, and would only add, that besides the casts of Polythalamia and small spiral mollusks, there is also a considerable number of green, red, and whitish casts of minute anastomosing tubuli, resembling casts of the holes made by burrowing sponges (Cliona) and worms.

In the Berlin Monatsbericht, for July, 1855, Ehrenberg gives an account of very perfect casts of Nummulites, from Bavaria and from France, showing not only chambers connected by a spiral siphuncle, but also a complicated system of branching vessels. He also gave at the same time an account of a method he had applied for the purpose of coloring certain glass-like casts of Polythalamia, which he had found in white tertiary limestone from Java. This method consists in heating them in a solution of nitrate of iron, by means of which they can be made to assume different shades of yellow and brownish red, still retaining sufficient transparency when mounted in balsam to show the connection of the different parts.

The interesting observations of Ehrenberg which are alluded to above, have led me to examine a number of the cretaceous and tertiary rocks of North America in search of Greensand and other casts of Polythalamia, &c. The following results were obtained :—

1st. The yellowish limestone of the cretaceous deposits of New Jersey occurring with Teredo tibialis, &c., at Mullica Hill, and near Mount Holley, is very rich in Greensand casts of Polythalamia and of the tubuliform bodies above alluded to.

2d. Cretaceous rocks from Western Texas, for which I am indebted to Major W. H. Emory, of the Mexican Boundary Commission, yielded a considerable number of fine Greensand and other casts of Polythalamia and Tubuli.

3d. Limestone from Selma, Alabama, gave similar results.

4th. Eocene limestone from Drayton Hall, near Charleston, South Carolina, gave abundance of similar casts.

5th. A few good Greensand casts of Polythalamia were found in the residue left on dissolving a specimen of marl from the Artesian Well at Charleston, S. C.; depth 140 feet.

6th. Abundance of organic casts, in Greensand, &c., of Polythalamia, Tubuli, and of the *cavities of Corals*, were found in the specimen of yellowish limestone, adhering to a specimen of Scutella Lyelli from the Eocene of North Carolina.

7th. Similar casts of Polythalamia, Tubuli, and of the *cavities of Corals*, and spines of Echini, were found abundantly in a whitish limestone adhering to a specimen of Ostrea sellæformis from the Eocene of South Carolina.

The last two specimens scarcely gave any indications of the presence of Greensand before they were treated with dilute acid, but left an abundant deposit of it when the calcareous portions were dissolved out. All the above mentioned specimens, contained well-preserved and perfect shells of Polythalamia. It appears from the above, that the occurrence of well-defined organic casts, composed of Greensand, is by no means rare in the fossil state.

I come now to the main object of this paper, which is to announce that the formation of precisely similar Greensand and other casts of Polythalamia, Mollusks, and Tubuli, is now going on in the deposits of the present ocean. In an interesting report by Count F. Pourtales, upon some specimens of soundings obtained by the U. S. Coast Survey in the exploration of the Gulf Stream, (See Report of U. S. Coast Survey, for 1853, Appendix, p. 83,) the sounding, from Lat. 31° 32′, Long. 79° 35′, depth 150 fathoms, is mentioned as "a mixture in about equal proportions of Globigerina aud black sand, probably greensand, as it makes a green mark when crushed on paper." Having examined the specimen alluded to by Mr. Pourtales, besides many others from the Gulf Stream and Gulf of Mexico, for which I am indebted to Prof. A. D. Bache, the Superintendent of the Coast Survey, I have found that not only is Greensand present at the above locality, but at many others, both in the Gulf Stream and Gulf of Mexico, and that this Greensand is often in the form of well-defined casts of Polythalamia, minute Mollusks, and branching Tubuli, and that the same variety of the petrifying material is found as in the fossil casts, some being well-defined Greensand, others reddish, brownish, or almost white. In some cases I have noticed a single cell, of a spiral Polythalamian cast, to be composed of Greensand, while all the others were red or white, or *vice versa*.

The species of Polythalamia whose casts are thus preserved, are easily recognizable as identical with those whose perfectly preserved shells form the chief part of the soundings. That these are of recent species is proved by the facts that some of them still retain their brilliant red coloring, and that they leave distinct remains of their soft parts when treated with dilute acids. It is not to be supposed, therefore, that these casts are of extinct species washed out of ancient submarine deposits. They are now forming in the muds as they are deposited, and we have thus now going on in the present seas, a formation of Greensand by processes precisely analogous to those which produced deposits of the same material as long ago as the Silurian epoch. In this connection, it is important to observe that Ehrenberg's observations and my own, establish the fact that *other* organic bodies than Polythalamia produce casts of Greensand, and it should also be stated that many of the grains of Greensand accompany-

ing the well-defined casts are of wholly unrecognizable forms, having merely a rounded, cracked, lobed, or even coprolitic appearance. Certainly many of these masses, which often compose whole strata, were not formed either in the cavities of Polythalamia or Mollusks. The fact, however, being established beyond a doubt, that Greensand does form casts in the cavities of various organic bodies, there is a great probability that all the masses of this substance, however irregular, were formed in connection with organic bodies, and that the chemical changes accompanying the decay of the organic matter have been essentially connected with the deposits in the cavities, of green and red silicates of iron, and of nearly pure silica. It is a curious fact in this connection, that the *siliceous* organisms, such as the Diatomaceæ, Polycistineæ, and Spongiolites which accompany the Polythalamia in the Gulf Stream, do not appear to have any influence in the formation of casts.

The discovery of Prof. Ehrenberg, of the connection between organic bodies and the formation of Greensand, is one of very great interest, and is one of the many instances which he has given to prove the extensive agency of the minutest beings in producing geological changes.

III. BOTANY AND ZOOLOGY.

1. *Wild Potatoes in New Mexico and Western Texas.*—We have received from Dr. A. J. Myer, U. S. A., through the Surgeon General, a detailed communication on the discovery in western Texas of what he takes to be the common potato (*Solanum tuberosum*, L.,) in a wild state, accompanied with specimens of the tubers and of the whole plant neatly dried and prepared. Dr. Myer first detected the plant on and near the Rio Limpio, and afterwards ascertained that it was pretty widely diffused throughout all that region and into New Mexico. The tuber, though small, being rarely as large as a hickory nut, have been gathered, cooked and eaten by officers and soldiers, and they proved to be both palatable and innocent. It naturally occurred to Dr. Myer that his discovery might be turned to useful account; that these wild potatoes would probably increase in size and improve in flavor under continued cultivation; and that, if the well-known potato-rot were owing, as many suppose, to an attack of minute Fungi, or to a general debility of constitution resulting from propagation for generation after generation by the tuber, and seldom renewed from seed, or from both these causes combined, the proper remedy would be to begin anew with a wild stock; and that these indigenous potatoes of our own country would furnish an excellent stock for the purpose, and one which might be expected to resist the disease for a long time, if not altogether.

Such, in brief, is the substance of Dr. Myer's commendable communication, made to his official superior, the Surgeon General, and by him offered for publication in this Journal. The article is too long to be inserted, however; especially as the facts and the suggestions it comprises have not the novelty which Dr. Myer naturally supposed they had. But his laudable endeavors and observations ought not to pass unnoticed; and having given this very brief abstract of his principal points,—which he

has ably but rather diffusely elaborated, we take the opportunity to remark :—

(1.) That the wild potato-plant in question is a true potato, but not of the same species as the common potato, the *Solanum tuberosum.* Indeed two tuberiferous species of Solanum occur in that region. One has a white and 5-parted corolla, and oblong-lanceolate leaflets mostly acute at the base, and is probably S. Jamesii of Torrey (which, if we are correct, was wrongly thought to be annual): the other, to which belong the specimens sent by Dr. Myer, has a blue, 5-lobed corolla, and ovate or roundish leaflets which are often a little heart-shaped at the base; and this if really undescribed, will soon be published under the name of *S. Fendleri.* Both are distinguished from *S. tuberosum* by having their leaflets uniform, or only the lowest pairs smaller, while in the common potato, and the 18 allied forms recognised by Dunal as species (but perhaps all mere varieties of one species,) a set of much smaller leaflets are interposed between the larger ones.

(2.) These wild potatoes have been known for some time. Passing by Dr. James, who gathered the one which bears his name, 36 years ago, but without knowing it was tuberiferous, we may attribute their proper discovery to that most excellent botanical explorer, Mr. Fendler, whose collection made nine years ago in the northern part of New Mexico, comprised both species, with their tubers. They were also gathered by Mr. Wright, in 1849, and are contained in his invaluable collection made between Eastern Texas and El Paso by the military road then opened through that region : and again in 1851 and 1852, they were gathered in various parts of New Mexico by Mr. Wright, Dr. Bigelow, and the other naturalists attached to the Mexican Boundary Commission, who recognised their near relationship to the common potato.

(3.) Some experience has already been had in cultivating other and nearly related species as a substitute for Solanum tuberosum, but without the good results that were hoped for. M. Alph. De Candolle relates (Prodr. 13, p. 677,) that the Mexican *Solanum verrucosum*, was cultivated two years in Switzerland, near Geneva, without being affected by the disease which destroyed all the crops of the common potato in the vicinity; but on the third year this also was attacked (Vide Alph. DeCand. Geogr. Bot., p. 815). A. G.

2. *Notes on Palæozoic Bivalved Entomostraca*, Nos. I. and II; on some Species of Beyrichia from the upper silurian limestones of Scandinavia and other regions British and Foreign; by T. Rupert Jones, F.G.S.—These important researches, illustrated by copper plates, are published in the Annals and Magazine of Natural History, for August and September, 1855.

3. *Cumæ.*—In a recent number of the Annals and Magazine of Natural History, Mr. Bates describes some Crustacea related to Cumæ, which had young and *therefore were adults.* This is not in conflict with the statement of Prof. Agassiz in this Journal, vol. xiii, p. 426, where he says: "In regard to the Crustacea called Cumæ, I cannot say positively that the group must as a whole be suppressed. But I can state with confidence that all the species of that genus which I have had an opportunity to examine alive—and I have watched three—are young of Palæmon

Crangon and Hippolyte." Prof. Agassiz in a recent letter (to J. D. Dana, dated Nahant, July 18th,) respecting these observations of Mr. Bates, writes that "they only show how extensive a field of observation remains untrodden among these little forms. Had Mr. Bates looked more fully into the embryology of Crustacea he would be better prepared to appreciate the close correspondence there is between the young of certain families and the adults of others, and know that these facts are not limited to the Macroura, as I have shown in my lectures on embryology, p. 62 to 69 : he would know that the eyes of even the highest Crustacea are sessile in the young, etc., and that such characters observed upon young Crustacea do not therefore prove them to be peculiar types, unless at the same time their reproduction be satisfactorily traced. Acknowledging Mr. Bates's interesting observation as proving that his Diastylis Rathkii is an adult animal, the question has made a real progress through his researches ; but it remains as certain as before, that *there are Cumæ which are larvæ of Macroura.*"

4. *Insecta Maderensia, being an Account of the Insects of the Islands of the Madeiran Group ;* by T. Vernon Wollaston, M.A., F.R.S. 634 pp., 4to, with 13 well-filled colored plates. London, 1854. John Van Voorst.

On the Variation of Species with especial reference to the Insecta, followed by an inquiry into the Nature of Genera ; by T. Vernon Wollaston, M.A., F.L.S. 208 pp., 12mo. London, 1856. John Van Voorst.

The first of these works is an elegant quarto volume containing full descriptions, of the Insects of the Madeira Islands, with remarks on their distribution, habits and varieties. The author went as an invalid to the regions he has so carefully investigated, and we rejoice with him in the invigoration he found in pursuing his favorite science among the heights and gorges of that delightful land. As giving some picture of the author, we quote a paragraph or two from his Introduction :—

"The admirer of Nature who has passed a long winter at the mountain's base, contented merely to gaze upon the towering peaks, which, though clear and cold at night, seldom reveal themselves during the day with sufficient constancy (through the heavy canopy of cloud which hangs around them) to warrant an ascent, hails with unbounded joy the advance of spring,—knowing that the time is at hand when he will be able to revel at large in this Atlantic paradise, in remote spots seldom visited by strangers, and at altitudes where the fierce elements of winter shall give way at last to perpetual sunshine and the fresh breezes of a calmer sea. There is something amazingly luxurious in betaking oneself to tent-life, after months of confinement and annoyance (it may be entirely,—*partially* it must be) in the heat and noise of Funchal. We are then perhaps more than ever open to the favorable impressions of an alpine existence;—and who can adequately tell the ecstasy of a first encampment on these invigorating hills! To turn out, morning after morning, in the solemn stillness of aërial forests,—where not a sound is heard, save ever and anon a woodman's axe in some far-off tributary ravine, or a stray bird hymning forth its matin song to the ascending sun; to feel the cool influence of the early dawn on the upland sward, and to

mark the thin clouds of fleecy snow uniting gradually into a solid bank,—affording glimpses the while, as they join and separate, of the fair creation stretched out beneath; to smell the damp, cold vapor rising from the deep defiles around us, where vegetation is still rampant on primeval rocks and new generations of trees are springing up, untouched by man, from the decaying carcases of the old ones; to listen in the still, calm evening air to the humming of the insect world (the most active tenants of these elevated tracts); and to mark, as the daylight wanes, the unnumbered orbs of night stealing one by one on to the wide arch of heaven, as brilliant as they were on the first evening of their birth;—are the lofty enjoyments, which the intellectual mind can grasp in these transcendent heights.

"It is needless however to pursue the picture further, for it is impossible to do justice to what *experience alone* can enable us to appreciate. And let not any one suppose that the varied objects and scenes of novelty which administer to our superior feelings, and charm the eye, in these upland solitudes are adapted only to the scrutiny of a naturalist, and are either beneath the notice of, or else cannot be sufficiently entered into, by the general mass,—for such is by no means the case. A single trial, we are convined, will be more than enough to prove the reverse, provided the adventurer be not altogether insensible to perceptions from without, or incurious as to the workings of the external universe around him. This however, we need scarcely add, is *sine qua non*,—for it has been well said that "he who wondereth at nothing hath no capabilities of bliss; but he that *scrutinizeth trifles* hath a store of pleasure to his hand: and happy and wise is the man to whose mind *a trifle existeth not*."

"The great expense necessarily attending the publication of a work like the present one will be a sufficient guarantee that it has been undertaken purely as a 'labor of love,' and with the sole aim (within its prescribed limits) of arriving at the truth. How far I have succeeded in this is a problem which must be solved by others: meanwhile I appeal boldly to *observation, in situ*, as the test by which I would most desire to be judged,—having but little fear of the experiment, and believing that we are never in so favorable a position for deciding on the relative importance of Zoological differences as when the local circumstances connected with them are taken into account. Where I have overlooked facts, or failed in my conclusions concerning them, I must crave that indulgence which is never denied to the honest inquirer even in a field so small as that throughout which my researches have been prosecuted,—researches which I am well aware can at the best add but an iota to our knowledge,—'A drop dissevered from the boundless sea.'"

The second work discusses a philosophical question in science through the facts the author has gathered in his entomological researches. While having no sympathy with the notion of species rising into higher species, he illustrates the relations of genera as follows, taking the ground that they are realities and have their well defined types or centres while on their borders they may blend with other genera.

"Taking the preceding considerations into account, the question will perhaps arise,—How then is a genus to be defined? To which I may

reply that, were I asked whether genera had a real existence in the animate world, my answer would be that they undoubtedly have,—though not in the sense (which is so commonly supposed) of abrupt and disconnected groups. I conceive them to be gradually formed nuclei, through the gathering together of creatures which more or less resemble each other, around a central type: they are the *dilatations* (to use our late simile) along a chain which is itself composed of separate, though differently shaped links,—the links being the actual species themselves, and the swellings, or nodes, the slowly developed genera into which they naturally fall. When I say "slowly developed," my meaning may possibly require some slight comment. It is simply therefore to guard against the fallacy, which I have so often disclaimed, that genera are abruptly (or suddenly) terminated on their outer limits, that the expression has been employed. Though I believe that a series of *species*, each partially imitating the next in contact with it, is Nature's truest system; yet we must be all of us aware that those species do certainly tend, in the main, to map out assemblages of divers phases and magnitudes, distinguished by peculiar characteristics which the several members of each squadron have more or less in common. So that it is only in the middle points that these various groups, respectively, attain their maximum,—every one of which (by way of illustration) may be described as a *concentric bulb*, which becomes denser, as it were, in its successive component layers, and more typical, as it approaches its core."

The main topic of the work is the variations which species undergo. He illustrates it by facts and urges the importance of its study as the foundation of our knowledge of species. With every species in nature, organic or inorganic, there appears to be a normal type admitting of librations in many of its characters, on either side through external influences; and the complete idea involves a knowledge of the extent and laws of these librations. We cite the following from the author's concluding chapter.

"As regards that most obscure of questions, *what the limits of species really are*, observation alone can decide the point. It frequently happens indeed that even observation itself is insufficient to render the lines of demarcation intelligible,—therefore, how much more mere dialectics!

To attempt to argue such a subject on abstract principles, would be simply absurd; for as Lord Bacon has remarked, the "subtility of Nature far exceeds the subtility of reasoning:" but if, by a careful collation of *facts*, and the sifting of minute particulars gathered from without, the problem be fairly and deliberately surveyed, the various disturbing elements which the creatures have been severally exposed to, having been duly taken into account, the boundaries will not often be difficult to define. Albeit, we must except those races of animals and plants which, through a long course of centuries, have become modified by man,—the starting-points of which will perhaps continue to the last to be shrouded in mystery and doubt. It would be scarcely consistent indeed to weigh tribes which have been thus unnaturally tampered with by the same standard of evidence as we require for those which have remained for ever untouched and free,—especially so, since (as we have already

observed) it does absolutely appear, that those species, the external aspects of which have been thus artificially controlled, are by constitution more tractile (and possess, therefore, more decided powers for aberration,) than the rest. Whether traces of design may be recognized in this circumstance, or whether those forms were originally selected by man *on account of* their pliability, it is not for me to conjecture; nevertheless, the first of these inferences is the one which I should, myself, be *à priori* inclined to subscribe to.

In examining, however, this enigma, *of the limits within which variation is* (as such) *to be recognized*, it should never be forgotten, that it is possible for those boundaries to be absolutely and critically marked out even where we are not able to discern them: so that the difficulty which a few domesticated creatures of a singularly flexible organization present, should not unnecessarily predispose us to dispute the question in its larger and more general bearings. Nor should we be unmindful that (as Sir Charles Lyell has aptly suggested) "some mere varieties present greater differences, *inter se*, than do many individuals of distinct species;" for it is a truth of considerable importance, and one which may help us out of many an apparent dilemma.

But, whatever be the several ranges within which the members of the organic creation are free to vary, we are positively certain that, *unless the definition of a species, as involving relationship, be more than a delusion or romance*, their circumferences are of necessity real, and must be indicated *somewhere*,—as strictly, moreover, and rigidly, as it is possible for anything in Nature to be chalked out. The whole problem, in that case, does in effect resolve itself into this,—Where, and how, are the lines of demarcation to be drawn? No amount of inconstancy, provided its limits be fixed, is irreconcilable with the doctrine of specific similitudes. Like the ever-shifting curves which the white foam of the untiring tide describes upon the shore, races may ebb and flow; but they have their boundaries, in either direction, beyond which they can never pass. And thus in every species we may detect, to a greater or less extent, the emblem of instability and permanence combined: although perceived, when inquired into, to be fickle and fluctuating in their component parts, in their general outline they remain steadfast and unaltered, as of old,—

> "Still changing, yet unchanged; still doom'd to feel
> *Endless mutation, in perpetual rest.*"

5. *On the Fresh water Entomostraca of South America;* by John Lubbock, Esq., F.Z.S., (Trans. Ent. 8vo, iii, N. S., Part vi) —Mr. Lubbock who has taken up the investigation of the Entomostraca with great zeal and success, describes in this paper four new species of Entomostraca from South America, *Cypris australis*, *C. brasiliensis*, *Daphnia brasiliensis*, and *Diaptomus brasiliensis*. They were collected by Charles Darwin, Esq.

IV. ASTRONOMY.

1. *Shooting Stars of August* 10, 1856.—During the night of Friday, August 8th, 1856, the weather at New Haven was stormy. The next night on account of the cloudy state of the sky and other obstacles, no observation for meteors was attempted by us.

On the night of August 10th–11th, observations were commenced by Messrs. Francis Bradley, Charles Tomlinson and myself. Until about half past one o'clock of Monday morning the sky was clear and favorable. From this time onward, clouds interfered more and more, so that by 2^h 50^m A. M. of the 11th we left the field. During the period of observation, about 3 hours and 45 minutes, we noted *two hundred and eighty three* different shooting stars, as follows:

11^h 5^m to midn.,		W. N. W.	21
"	"	N. E.	12
"	"	S.	14——47
Midn. to 1 A. M. 11th,		W. N. W.	54
"	"	N. E.	27
"	"	S.	19——100
1 to 2 A. M.,		W. N. W.	31
"	"	N. E.	21
"	"	S.	21——73
2 to 2 50^m A. M.		W. N. W.	23
"	"	N. E.	24
"	"	S.	16——63

In general characteristics these shooting stars resembled those of the August period in former years. The visible paths of a large part of them, if traced back, would meet in the vicinity of the sword-handle of Perseus. Some moved in other directions, and a few appeared to go towards the general radiant. Several of them equalled in brilliancy stars of the first magnitude, and left sparkling trains behind them.

The present being leap-year, it is probable that the meteors were more numerous on the night of the 9th–10th, than on the night succeeding.

E. C. Herrick.

2. *Astronomical Observatory at the University of Mississippi*, (from a letter to the editors dated, University of Mississippi, Oxford, July 19, 1856.)—I think it may interest the scientific world to know, that the Board of Trustees of this University have sanctioned the erection of an Astronomical Observatory at this place, and have authorized a contract for a transit circle similar to that introduced by Mr. Airy at Greenwich. Other instruments will be supplied hereafter. The building provides for a first-class equatorial telescope.

On the completion of the circle, regular observations will be instituted and constantly sustained here. An astronomer will be employed, with no other business but to observe.

It is hoped that Mississippi will now make a beginning—the first earnest beginning in the Southern States—to contribute effectually to the

progress of the noblest of sciences; and it is also hoped that this institution may be the means of awakening to activity, and leading on to its full development, that native talent in southern youth, which, when it now appears, too often relapses into inaction, for the want of a field for its exercise.

The principle which the Board of Trustees of this University have distinctly recognised, as that which is to govern all their future policy in building up this institution, is that they will employ all their resources as fast as they become available, in adding to the means and appliances accumulated here for acquiring or imparting knowledge in all its departments; and that, since the means will not probably be wanting to make the institution equal in all visible respects to the best on the continent, they will not be content to see it occupy, in any particular, an inferior position.

They are therefore making steady and large appropriations for the increase of the library, for additions to the stock of philosophical and chemical apparatus, for minerals, shells, &c., &c., all of which are rapidly giving to the University the aspect of an institution of long standing.

The earnest desire of the Board is also to encourage here a spirit of original investigation, by putting the means of research into the hands of their officers, and it can hardly be doubted that when the arrangements shall have been carried out, which this enlightened policy has suggested, (which will be within two or three years,) Mississippi, through her University, will place herself in a very honorable relation to the progress of intellectual improvement in the world. B.

V. MISCELLANEOUS INTELLIGENCE.

1. *Observations on the climates of California;* by Mr. GEORGE BARTLETT, (from a letter dated, Providence, June 27, 1856.)—The natural forces which produce the various meteorological phenomena of California, are much less numerous than in the eastern part of the continent, and act on a much larger scale, and they are therefore more easily understood. In fact, with a knowledge of three great causes, the peculiarities of the several climates of California would have been readily anticipated. These are; 1st, the cold ocean current which rolls along the coast from northwest to southeast; 2d, the direction of the winds; 3d, that property of air by which its capacity for containing moisture is increased with the elevation of its temperature. The ocean current will no doubt be thoroughly examined in the course of the Coast Survey. Dr. Gibbons, of San Francisco, ascertained at one time its temperature to be 54° Fahrenheit.

Now, during the summer months, as soon as the rays of the sun have warmed the air over the land, it becomes rarified, and the colder and heavier air rushes in under it from the ocean, producing that sea-breeze, which lashes the coast of California with so remarkable regularity, almost every afternoon throughout the summer months, driving the sand through the air, and compelling people to put on over-coats and kindle fires, even under that cloudless sky and in those low latitudes. As this cold air, from the ocean is warmed by the land, of course its capacity for holding moisture is increased, and instead of there being any tendency to

form clouds and to rain, it becomes a very drying air, absorbing water from everything that it touches. This is the very simple and plain explanation of the dry season.

The most wonderful phenomenon of the California climates, is the marked manner in which they are cut in two by no higher chain of mountains than the Coast Range. This range extends along the coast of California from latitude 34½ to 41½, and is so low, that snow collects during the winter only on a few of the highest peaks. Now, while the western side of this range has the cold summer above described, the valley on the east side is one of the hottest portions of the earth. This valley, through which flow, in opposite directions, the waters of the Sacramento and the San Joaquin, extends about 400 miles from north to south, with an average breadth of perhaps 60 miles, from the Coast Range on the west to the Sierra Nevada on the east. It is a very flat valley, much more level than the western prairies, and occupies the great portion of the interior of California. It has been quite difficult to obtain exposures of a thermometer which were unobjectional. In the cloth tents and stores which were in use in 1849 and '50, the temperature would range in the warm days from 115° to 120°. On the north side of a large tree, also in a wooden cabin covered with earth, a friend of the writer observed the mercury at 110° and 112° during many of the days of 1850. On the north side of a large two-story frame house, with but one other house near, and that one several rods distant, the writer has observed the mercury at 109°. But Dr. Haille at Marysville, by hanging his thermometer in a draft of air in the back part of his office, where it was shaded by high buildings around, succeeded in keeping the mercury down to 102° during the summer of 1852. The sun rises clear in the east, rolls up over the heads of the inhabitants, drying and scorching everything in sight, and sinks into the west—"One unclouded blaze of living light." And this is repeated day after day, and month after month. The hottest time of day is about half-past five in the afternoon. The nights are cool; you need two or three blankets to sleep comfortably even in the hottest part of the summer. A plate of butter set in a common wooden house, will be perfectly liquid at night, and entirely hard in the morning, and these changes will occur every twenty-four hours for months in succession.

The change from the cold climate of the coast to the heat of the valley is marvellous. You go on board a steamboat at San Francisco at four o'clock in the afternoon, and find the passengers, all dressed in winter clothing, flannels and overcoats, huddled around the stove in the cabin with its hot anthracite fire. The next morning at sun-rise, you find yourself going up the Sacramento river, and, as your state-room is insufferably hot, you put on the thinnest summer clothing, and go out on the guards of the boat, oppressed with the heat, and the perspiration starting from your pores.

There seems to be some doubt whether the great difference between the climate of the coast and that of the interior, is to be wholly attributed to the Coast Range. From Benicia this range trends inland, leaving quite a broad tract between it and the sea. On the east side of the bay of San Francisco, between the bay and the mountains, is a tract of level land,

five to ten miles in width, of great fertility and which, in the month of May, is almost one unbroken field of waving grain. This plain is swept every afternoon in summer by the sea-breeze, and there is no doubt the breeze here is less violent and less cold than it is in San Francisco, though nothing intervenes but a smooth sheet of water.

This plain may be considered a portion of the valley of San Josè, which extends southerly from the neighborhood of San Francisco, some 70 or 80 miles, between the broken hills of the coast and the main ridge of the Coast Range. This valley, as well as others similarly situated, among the straggling ridges of the Coast Range, such as Nappa, Santa Cruz, San Pablo, &c., enjoys the most delightful climate in the world. The fierce gale which drives through the streets of San Francisco, is here tempered into a bland and bracing breeze. The malaria, so prevalent in the great valley of the interior, is here unknown. The husbandman reaps the abundant harvests of the fertile soil in *health* and *comfort*. For two months he reaps, leaving the grain in the field, and for two months more he threshes and winnows, allowing the bags of grain to stand where they are filled, without the slightest apprehension of a shower. No thunder ever disturbs the serenity of the sky. These delicious valleys are indeed the Edens of the west.

Besides these three climates in California, that of the coast, that of the interior, and that of the small valleys which lie among the scattered branches of the Coast Range, there is yet a fourth, the climate of the mountains. But this, with the exception of its dry season, has merely the characteristics of other mountain climates, the heat decreasing with the altitude.

These are the summer climates. In the winter there is no perceptible difference in the weather throughout California, except the very small difference caused by the latitude, and the very great difference caused by the altitude. In the lowlands the climate is very similar to April in New England, or perhaps, it may be more nearly compared to our spring, from the middle of March to the middle of May. There is no snow, though frosts are frequent. Near San Francisco, peas are planted in October, and strawberries are to be had every day in the year. Still, ice has been known to form half an inch thick in a night. On the mountains, snow falls to a great depth. Indeed, the stories which are told of its depth are incredible, many persons having assured the writer that it would average ten feet. Nearly all the rains are with the wind from the south, probably caused by the simple cooling of the air in moving from a lower to a higher latitude. Occasionally, about once in a season, there is a rain with the wind from the north. The climate is remarkably serene. There are very few gales or high winds. In the winter it is generally calm. In the summer, in the interior, there is generally a very mild breeze, more than half of the time from the south; and, very unaccountably, the wind from this direction is generally cooler than the wind from the northwest. Probably the reason why there is no thunder and lightning, or so little, is, that there are no showers or clouds in the summer. That the sea breeze, with its accompanying dryness, does not continue through the winter, is probably attributable to the diminished force of the sun's rays in his withdrawal to the south.

2. *Apparatus for taking specific gravity;* by Messrs. Eckfeldt and Dubois, (Proc. Amer. Phil. Soc., vi, 193.)—The apparatus for taking specific gravity of solids, is essentially a tin cup with a spout at the side. Five vessels are here shown, of different sizes and shapes, to suit different cases. Four of these are cylindrical, ranging from six to ten inches high, and from two to five inches in diameter. The tall one (ten inches by two), is intended for the trial of silver spoons and forks, or articles of similar shape; the others are adapted to lumps of stone or metal, or blocks of wood, of various sizes. The fifth vessel is rectangular, measuring $6\frac{1}{2}$ inches high, $1\frac{3}{4}$ inches long, and $\frac{1}{4}$ inch broad, being intended for coins, not smaller than the half eagle or quarter dollar, and for small medals and gems of admissible size. This vessel is provided with a brass plate, as a *plunger*, for diminishing the surface. The smaller vessels are set firmly in mahogany blocks, to insure steadiness in the operation; and these blocks have screw feet, for convenience of levelling. The spouts extend upward, with a curve outward, the beak being far enough below the top of the cup to allow for the space to be taken up by the specimen, that it may not force the water over the top nor leave any point uncovered by water. The aperture of the spout is tapered to the one-sixteenth of an inch, and a small bit of wire projects downwards from the beak, to carry the drops of water properly. A small cup is placed directly under, to catch the water displaced, and a brass weight, equal to the weight of this cup when empty, is found convenient (though not necessary) as a counter-weight.

When the operation is to be performed, suppose upon a gold or silver ore, the ore is first weighed, and afterwards its surface is moistened. The vessel is then nearly filled with water, and so much as is superfluous, or above the level of the beak of the spout, runs or drips off, to a final drop. The small cup is then set under the beak, and the lump is carefully lowered into the vessel by a hair wire or waxed thread. This, of course, displaces its own bulk of water, which runs off into the small cup, gradually coming back to the former level, by a final drop. The weight of this water is the divisor, the weight of the lump the dividend, and the quotient is the specific gravity.

In connection with this apparatus, the following miscellaneous remarks are offered to the Society.

The opening of the gold mines of California brought out a great number of beautiful specimens of gold in the matrix (or mingled with quartz) of the most fanciful forms, and every variety of size and value. In many cases it was presumed, by the holders of these prizes, that they would bring more money, as curiosities, than as bullion; and at any rate, very many owners were unwilling to have such attractive specimens spoiled until they had been sufficiently exhibited. At the same time, it was always desirable to know, pretty nearly, how much gold was actually contained; and, to obtain such estimates, upon what was supposed to be reliable authority, many of these specimens were brought to the assay office of the mint. They came at a time when we were overpowered with the legitimate business of the office, and yet it seemed impossible to refuse such requests; and, for a considerable time, such employment was interesting as a matter of scientific inquiry. Especially when we could compare our estimates with the more definite and accurate re-

sults obtained by putting specimens or "nuggets" through the regular routine of melting and assay. On one occasion a lump, weighing over 200 pounds, came to us for this purpose. It was sent by the Isthmus route, at a time when transportation was enormously dear, and having visible gold on the surface, was expected to be rich throughout the mass; and, with this expectation, was on the way to London, to make an impression upon the stock market there. By the aids of a very large steelyard beam and copper kettle, we were enabled to take the specific gravity, but could not make it higher than that of compact quartz. The result seemed so questionable, that we obtained permission to break up the rock, and found that what little gold it contained was at the surface.

Not only were ores brought to us from California, to be estimated, but also from other mining regions, and of various metals; but chiefly gold and silver. As the specimens were of all sizes, these demands upon us often proved embarrassing, since it was necessary to have beams suited to them, and with attachments for weighing in water. We therefore had frequent recourse to the method advised by the elder Dr. Patterson (formerly President of this Society), which consisted in using a jar or pitcher, rather larger than the specimen, and not over-large at the mouth; this was filled with water up to a marked line; and then, by introducing the specimen, and bringing back the water to the same line, so much water was removed as was just equal in bulk to the bulk of the specimen; the weight of this water gave the divisor, the weight of the specimen (taken while dry), the dividend, and the quotient was the specific gravity.

The results thus obtained were, generally, as satisfactory as those by the usual method. And here it may be interesting to cite a few examples from our minutes, of specimens estimated by one or other of the processes mentioned, and afterwards melted down and assayed as regular deposits.

1. A lump of quartz, containing gold, found by two Mexicans of the "Sonorian camp," in California, weighed 265½ ounces: assuming the quartz at the sp. gr. of 2·60, the amount of gold appeared by sp. gr. of the lump, to be 209½ ounces; the actual amount was 211⅛ ounces.—2. Another lump, where we assumed the matrix at 2·64, gave an estimate of 100⅛ ounces of gold; the actual product was $100\frac{1}{10}$ ounces.—3. Four pebbles taken together, estimated at 77 ounces; actual content $76\frac{8}{10}$ ounces.—And, lastly, a lump which had been bought in California for 800 dollars, and which weighed 408½ ounces, gave an estimate of 89½ ounces, or 1572 dollars, taking the matrix at 2·63; the actual yield was $91\frac{2}{10}$ ounces, or 1602 dollars; the fineness being 850 thousandths. In this case there was an error of 30 dollars, or about two per cent. upon the value; an amount of error to which such specimens are liable, with any apparatus.

But it was obvious that the method of displacement required a series of vessels specially adapted to the operation, to compete with weighing in closeness of results. After a good deal of reflection and experimenting, in which many modifications of shape and arrangement were tried and discarded, and which it would be cumbersome to notice in this place, the apparatus now shown was found to answer best. In practice it is really a pleasant and satisfactory substitute for the tedious and irk-

some method usually resorted to. Some few precautions must, of course, be attended to. The vessel must stand firmly. If at first the water will not flow, or flows fitfully, the obstruction will be removed by blowing a little in the spout.

An investigation of some interest, growing out of this matter, may properly be noticed. Where we are operating on substances of low specific gravity, say wood or stone, a drop or two of water, or the size of the drop, in tapering off the divisor, is of no consequence. But it is otherwise in the case of a gold coin, for example:—in a double eagle, the difference of one drop of water (ordinarily about a half-grain) in the divisor, would affect the result to the extent of 0·3, which, carried into the fineness, would make a difference of 15 or 20 thousandths; and in the case of a half-eagle, the uncertainty of result would be proportionally increased. The question then arose, what fluid, or what modification of water, will afford us a smaller drop? for, as was just observed, a half-grain is, on the average, the smallest of clean water that will detach itself by its own weight. Very much depends, of course, upon the size of the aperture, in the measure of drops of fluid; one drop of water from a large beak weighed 1½ grains. In the Dispensatory of Drs. Wood and Bache, there is a table of the experimental results of Mr. Durand, showing the number of drops of different liquids equivalent to a fluidrachm (page 1405). The differences are very remarkable; distilled water, for instance, being set down at 45 drops, and pure alcohol at 138 drops. And in our own experiments, the drop of alcohol was about one-third the weight of the drop of water, from the same pipette. This seemed to point to alcohol as a substitute; but there were obvious objections, and a much better vehicle was found in *soapy water*.

The best white soap, sold at the shops, is of the same specific gravity as water, and its mixture with water makes no change, in that respect. When the mixture is as strong as children use for blowing bubbles (we cannot conveniently give this measure in figures), the cohesion or tenacity of the water is so much weakened that the drop is reduced to one-tenth of a grain. No other fluid makes so small a drop as this. And there is the further advantage, that soapy water, though excellent for making bubbles, is less liable to retain them below the surface than pure water. So small a drop, of course, makes the experiment more tedious, and, by using less soap, the size of the drop will be, in many cases, advantageously increased. * * * * *

3. *Discovery of Palæozoic Fossils in Eastern Massachusetts;* by Prof. W. B. Rogers, (from a letter to J. D. Dana, dated Boston, August 13, 1856.)*—You will, I am sure, be surprised as well as pleased by the news I am about to tell you. You are aware that the altered slates and grits which show themselves interruptedly throughout a good part of Eastern Massachusetts, have with the exception of the coal measures on the confines of this State and Rhode Island, failed hitherto to furnish geologists with any fossil evidences of a Palæozoic age, although from aspect and position they have been *conjecturally* classed with the system of rocks belonging to this period. Indeed the highly altered condition of these beds generally, traceable no doubt to the great masses of syenite and other igneous materials by which they are traversed or enclosed,

* This important paper was received too late for insertion under Geology.

would naturally forbid the expectation of finding in these any distinguishable fossil forms.

Lately, through the kindness of Peter Wainwright, Esq., of this city, I have been led to examine a quarry in the belt of silicious and argillaceous slate which lies on the boundary of Quincy and Braintree, about ten miles south of Boston, and to my great surprise and delight I found it to be a *locality of Trilobites.*

It appears that for several years past the owner of the quarry, Mr. E. Hayward and his family, have been aware of the existence of these so-called images in the rock, which from time to time they have quarried as ballasting material for wharves, but until now the locality has remained entirely unknown to science.

The fossils are in the form of casts, some of them of great size and lying at various levels in the strata. So far as I have yet explored the rock, they belong chiefly if not altogether to one species, which on the authority of Agassiz, as well as my own comparison with Barrande's description and figures, is undoubtedly a *Paradoxides.* Of its specific affinities I will not now speak, further than to remark that the specimens agree more closely with Barrande's *P. spinosus* than with any other form.

As the genus Paradoxides is peculiar to the lowest of the Palæozoic rocks in Bohemia, Sweden, and Great Britain, marking the Primordial division of Barrande and the Lingular flags of the British Survey, we will probably be called upon to place the fossil belt of Quincy and Braintree on or near the horizon of our lowest fossiliferous group, that is to say, somewhere about the level of the Primal rocks, the Potsdam sandstone, and the Protozoic sandstone of Owen, containing Dikelocephalus in Wisconsin and Minnesota. *Thus, for the first time are we furnished with the data for establishing conclusively the Geological age of any portion of this part of ancient and highly altered sandstones, and what gives further interest to the discovery, for defining in regard to this region the very base of the Palæozoic column as recognized in other parts of the globe.*

The newly discovered fossil is, I am satisfied, identical with the *Par. Harlani* described by Green in his monograph of N. American Trilobites, from a specimen of *unknown locality* procured through Dr. Harlan from Mr. Alger some twenty-five years ago. I draw this conclusion from the close agreement of a nearly complete specimen of the Quincy Trilobite with the cast of P. Harlani and from the identity of the rock as described by Green, and at once recognised by Mr. Alger's experienced eye on seeing my collection of Quincy specimens.

In this connection I find in Barrande a remark which, at the same time that it is historically curious, has an interesting bearing on the specific affinities of our fossil. He observes, "We see in different collections, especially in that of the School of Mines and the British Museum, under the name of Paradoxides Harlani, from the United States, a cast of a Trilobite, which appears to us to be identical with P. spinosus of great size, such as found at Skrey in Bohemia."

It thus appears that the vagrant Par. Harlani, so long an obscure exile has at last been restored to its native seat, to take a conspicuous place in the most ancient dynasty of living forms belonging to the geology of New England.

The interest of this discovery of a locality of Paradoxides in our neighborhood is not a little heightened, by the circumstance of its being the only instance, as I believe, in which forms of this genus have been found anywhere on the continent. Barrande after speaking of its restriction to Protozoic strata in Bohemia, Sweden, Wales, &c., has the following observations on this subject: "The presence of Paradoxides has not been satisfactorily proved in any other Silurian region, although this generic name has been applied to North American forms, P. Boltoni and P. Harlani. The first of these is known to be a Lichas and *we know nothing of the other* The care with which Hall has described the Trilobites of the Lower Silurian rocks of the country in question is sufficient proof that he had not discovered any trace of Paradoxides at the time of publishing the first volume of the Palæontology of N. Y." I may add to this, that in no subsequent publication have I seen any reference to the finding of fossils of this genus in the rocks of this continent.

The occurrence of well preserved fossils among rocks so highly altered and so contiguous to great igneous masses as are the fossiliferous slates of Quincy, may well encourage us to make careful search in other parts of Eastern New England, where heretofore such an exploration would have been deemed useless. Although we cannot hope to build up the geological column of New England from the Protozoic base just established to the carboniferous rocks, supposing all the intervening formations to be represented in this region, we may at least succeed in determining by fossils hereafter discovered some of the principal stages in its structure, and thus relate its strata definitely to the great Palæozoic divisions of our Appalachian Geology.

4. *Hailstorm in Guilford County, N. C.*—On the 9th of June, 1856. a hailstorm of unusual violence passed over a portion of Guilford County, N. C. An observer at Hillsdale in that county, gives the following description. "The cloud came up from the SW about 12. The storm began with rain, thunder and lightning. In a few minutes hailstones of great size began to fall, dashing in exposed windows, and splitting the shingles on the roof of the building in which I was. The rain continued an hour after the hail ceased. As soon as it was safe to go out, some of the hailstones were brought in. One measured eight inches in circumference, and I concluded it must have been nine or ten when it fell, as there had been so much rain and that a very warm one. The weather was very hot, and there was no change of temperature during the week following. This hailstone was a perfect globe. Others measured as large in one direction, but they were flat."

"The grounds around us were so completely covered with leaves and boughs of trees from the oak grove in which we were, that we had little chance to know what actually fell about us. A mile westward the storm was still more severe. The trees have a strong appearance of winter, and fields of wheat have been turned over to the use of cattle. There was destruction of windows and of small animals, and a few wayfarers were severely beaten. The storm extended about fifteen miles in one direction and five or six in the other. The hail fell in *lines*, a field here and a garden there being destroyed, while intermediate ones were left uninjured. The hail had a strong flavor of turpentine. This is the testimony of persons testing it at different and distant localities."

5. *Monks Island or Colombian Guano;* by Dr. A. S. Piggot. (Proc. Amer. Phil. Soc., Philad. vi, 189).—In the spring of 1855, there was brought into the port of Baltimore a hard, rocky substance, which was offered for sale under the name of Colombian Guano. At first, there was a great effort made to involve in mystery the whole history of the article, its locality being carefully kept secret. Gradually, however, it became known that it was found on Los Monges, a collection of keys at the entrance of the Gulf of Maracaibo. It has also been found on El Roncador, off the Musquito coast, on Aves and various other keys of the Caribbean Sea. On Los Monges, it forms, as the captains who procured it say, a thin polished crust over the entire surface. Below this crust lies the common Mexican guano. In some instances, however, this same smooth incrustation covers thinly the jutting points of primitive and metamorphic rocks. I have before me a splinter of rock of this kind, crested with an inch-thick deposit of this guano; and I have seen many in which the white crust formed a thin lamina over the surface. Many such were brought in, in the first cargo, which will account for the large amount of sand in the subjoined analysis. Only the ground guano was thus sent to me, so that the analysis represents the commercial article, not a selected specimen. The actual guano contains only about 0·5 per cent of siliceous matter.

The unusual quantity of phosphoric acid, contained in this substance, attracted attention, and many analyses were made of the new guano. The habit of calculating the phosphates in these Mexican guanos as bone earth, or tribasic phosphate of lime, led some chemists into grievous errors. The new material was, in one breath, called a superphosphate of lime, and in another, said to contain from seven to eleven per cent of *free phosphoric acid.* In common with other chemists of Baltimore, on the first importation of this guano, I made an analysis of it, and found it to contain a large proportion of phosphates, but expressed no opinion as to their composition. At last, however, hearing so much said about the soluble phosphoric acid in this substance, I examined it more carefully, and found but little of this acid soluble in water, and none of it *free.* I obtained the following results:

Phosphoric acid,	41·62
Sulphuric acid,	3·65
Chlorine,	0·5
Lime,	33·83
Magnesia,	3·27
Iron,	trace.
Fluorine,	trace.
Sand (consisting chiefly of primitive rocks in powder,)	5·34
Water (hygrometric,)	2·15
Organic matter, salts of ammonia (containing 0·23 of ammonia) and combined water,	8·62
Loss, in which are the alkalies (not estimated,)	1·47
	100·00

The proportions of the phosphates vary in different samples. Thus, in one specimen, recently examined, there was a very small proportion of magnesia and 4·23 per cent of phosphate of iron.

The organic matter was partly soluble in hydrochloric acid, and partly in potash. A cursory examination of it seemed to indicate that it consisted chiefly of humus and the acids of the crenic group.

From this analysis I thought myself justified in announcing that the lime and magnesia in the compound under consideration are combined with the phosphoric acid so as to form a tribasic salt, in which one atom of water substitutes one atom of alkaline earth, according to the formula $2MO, HO, PO_5$. A subsequent examination and recalculation of my results has convinced me that the announcement was somewhat premature, and that the analysis would not fully bear the construction put upon it. I have, however, never changed the opinion then advanced, as the discrepancies are slight and easily accounted for.

The statement of my views led to further investigation. Among others, Dr. Campbell Morfit examined the substance, and came to a different conclusion from that at which I had arrived. Drs. Higgins and Bickell, Chief and Assistant State Chemists of Maryland, shortly after published a paper in which they agreed with me in the main. Their analysis was more elaborate than mine, and comprised two distinct examinations; one of the white, polished crust, the other of the body of the rock. Without going into minutiæ, I will simply state that they found the exterior layer to contain phosphates of lime and magnesia, of the formula $3MO\ PO_5$, while, in the body of the rock, the salts were composed, as I had previously announced. They also ascertained that in the outer layer the sulphuric acid was combined with soda, while in the body of the rock it was united to lime.

6. *On the Monks Island Guano;* by Dr. A. A. Hayes (Proc. Boston Soc. Nat. Hist., v, 349).—Dr. Hayes first describes the general characters of the hardened guano, mentioning its rounded nodular surface, its hardness as above that of fluor, and its specific gravity as averaging 2·440. He states that the arenaceous variety consists of grains about as large as mustard seed, and that this granular structure is entirely lost as it passes into the solidified guano, which forms a crust or layer over it. The two kinds differ not very much in composition. After giving the results of analyses and pointing out the existence of a very large percentage of bone, phosphate of lime, and magnesia, he argues that the guano has been formed mainly from fish-bones. With regard to the change in consolidation he observes.

"Recurring to the composition of guano-rock, we see that the proportion of organic salts and other organic matter, is much larger than exists in the guano from which it is derived. The physical characters of the rock are modified by the presence of these compounds, but the most remarkable change is that from a granular to a compact solid. This change could be effected by infiltration, as takes place from calcareous waters; but as the rock guano is above the mass producing the soluble organic salts, it is necessary to consider another condition.

"When water holding saline matter in solution evaporates from the surface of the earth, pure water alone escapes, while the saline and colored organic compounds remain at or near the surface. In accordance with this law, the saline matters which can be dissolved, and the colored matters which can be suspended, in water, rise to the surface, and so long as capillarity can act, they are deposited in the porous parts, grad-

ually filling the pores and consolidating the surface. Doubtless, while this process is proceeding, rains carry back a part, which is to be raised anew, until finally the surface-rock, no longer pervious, becomes cemented into the compact state it now presents, by this action of capillarity."

7. *Neo-Macropia.*—In vol. viii, p. 442, 2nd Series of this Journal, I gave a brief notice of this kind of abnormal vision. Since that time, 1849, I have found many other cases. Dr. DeForest of the Syrian Mission describes to me a marked instance of it in a native girl belonging to the mission at Beirut. A striking instance in this city is now before me, a boy near fourteen years old. He never saw objects distinctly, till he happened to put on the spectacles used by his grandfather. He now uses constantly the convex glasses suited to ordinary eyes of persons eighty years of age. Indeed the focus is much too short for my old eyes, as his glasses have the principal focus less than six inches, while mine is fourteen inches. Without glasses he can see very little, and with them at all distances distinctly.

C. D.

8. *Artificial light for taking photographs.*—A very brilliant light has been produced by directing a stream of oxygen gas into the flame of coal gas which had been previously made to pass through cotton and naphtha in order to surcharge it with carbon. With this light, using a reflector, a photograph of an engraving could be taken by the camera in a very short time.—Roy. Cornw. Polytech. Soc. 1855, xli.

9. *Waters of the Dead Sea.*—Analysis by F. Moldenhauer (Ann. Ch. u. Pharm., xcvii, 357): Solid portion 13·6111 per cent; composition: chlorid of potassium 2·3910, chlorid of sodium 2·9575, chlorid of magnesium 6·8121, chlorid of calcium 1·4719, bromid of magnesium 0·1838, sulphate of potash, 0·0627 = 13·8790. Specific gravity 1·1160. The water was collected in June of 1854.

10. *Density of the Waters of the Caspian Sea;* by A. Moritz.—Mr. Moritz visited the Southwest coast of the Caspian in the summer of 1850, and obtained the following determinations of the density.—At Derbent, 1·00524, at 22° R.; at Baku, 1·00616 at 22·1° R., and 1·00976 at 8·1° R.; at Persien, 1·00583, at 22·6° R.—Bullet. St. Petersb. Phys. Math., xiv, 162–168.

11. *Well in the Desert of Sahara.*—A well sunk at Tamerna in the Sahara to a depth of 66 yards, gave on the 9th of June last a jet or flow of water amounting to 3600 litres per minute.

12. *Composition of the Water of the Delaware River;* by Henry Wurtz.—The water analyzed by Mr. Wurtz, as cited in this volume, page 124, was taken from the Delaware River at Trenton, New Jersey.

13. *Aluminium.*—A watch whose works were made of aluminium was on exhibition at the Paris Exhibition.

14. *Officers of the Academy of Science of St. Louis, for* 1856.—President, George Engelmann, M.D.; 1st Vice President, Hiram A. Prout, M.D.; 2nd Vice President, Nathaniel Holmes; Secretaries. Benj. F. Shumard, M.D., Wm. H. Tingley, M.D.; Treasurer, J. B. Eads.

15. Obituary.—*Professor John Locke.*—Professor Locke of Cincinnati, died on Thursday the 10th of July last, at the age of 65. He had long been distinguished for his zeal and successful labors in many departments of science. His papers in this Journal treat of topics connected with galvanism and electro-magnetism, in which he invented some new pieces

of apparatus, geology and palæontology, the earth's magnetism, and the invention of the Electro-chronograph, which he claimed the honor of, against one or two rivals. On the subject of the earth's magnetism he extended much our knowledge, by his explorations over the regions of the Northern Mississippi and Lake Superior. As a writer in Cincinnati observes, "he was an ardent student, a profound scholar, an indefatigable explorer into the causes of things, and a man of pure reputation, of genial nature, and of all the virtues that adorn private life."

16. *Manual of Coal and its Topography*, illustrated by original drawings chiefly of facts in the Geology of the Appalachian Region of the United States of North America; by J. P. Lesley, Topographical Geologist. 224 pp. 12mo. Philadelphia, 1856.

The scope of this work is hardly indicated in the title. It does not take up the subject of coal in its economical bearings, but rather in its lithological and topographical relations, as illustrated in the Appalachian Regions, especially in Pennsylvania. Neither is it restricted to the subject of Coal, but enters freely into the general topics of mountain structures and forms, the origin of mountains, formation of valleys, theory of drift, topographical drawing, and directions to geological and topographical surveyors, yet mainly from an Appalachian point of view. The author was formerly an assistant in the Geological survey of Pennsylvania, under Prof. H. D. Rogers. He has been an attentive observer, embodies much that is new in his works, and writes with the earnestness of a zealous investigator and thinker, and the positiveness of one who believes that he has the truth, although sometimes assuming more, we think, than the subject or facts will authorize. The illustrations are original and generally excellent. The volume is dedicated to James D. Whelpley and Andrew A. Henderson, who were once assistants in the Pennsylvania Geological survey.

The point in the volume that will excite most remark, is the claim advanced in behalf of Mr. Whelpley and Mr. Henderson, of having first unraveled the Appalachian mountain system. Professor H. D. Rogers published his views on the subject at considerable length in the Transactions of the Geological Association of 1842, having presented them to the Association at the meeting in that year. Mr. Lesley makes no allusion to the paper of Prof. Rogers, and does not mention his name in connection with the subject. "Years of patient toil," he says, "it cost *us* to unfold the mysteries of the Pennsylvanian and Virginian range," including himself with the two persons just mentioned. These gentlemen had been assistants of Prof. Rogers previous to the publication of that paper, and the facts which they observed, were then collected. To substantiate such a claim it is necessary to prove that Prof. Rogers was dependent on the suggestions of these gentlemen for the theory he has advanced, and as preliminary, to settle the legitimate relations between an assistant and the superintendent in a Geological survey.

17. *A Treatise on Land Surveying;* comprising the Theory developed from Five Elementary Principles, and the Practice with the Chain alone, the Compass, the Transit, the Theodolite, the Plane-table, etc. Illustrated with 400 engravings and a Magnetic Chart; by W. M. Gillespie, A.M., Civ. Eng., Professor of Civil Engineering in Union College. New York: D. Appleton & Co.—This treatise bears abundant evidence in its whole

structure, that it is the work of one who understands well both the practice and theory of his art. It unites great simplicity of illustration and an exuberance of practical detail, with a clear exhibition of scientific principles. Full directions are given as to the various operations in the field, the uses of instruments, the methods of measurement, calculation, platting and mapping; and at the same time, demonstrations are freely supplied, so that the faithful student will come forth intelligent as well as skilful. The volume contains a chapter on the Government system of surveying the public lands; also Traverse Tables, a Table of chords, of sines and cosines, and of tangents and cotangents; and a map of the United States showing the magnetic variation, displaying to the eye a subject of great importance to the Surveyor.

18. *Annals of the Astronomical Observatory of Harvard College.* Vol. I, Part I. cxci pages, 4to. Cambridge, 1856.—The Cambridge Observatory, through funds resulting from the will of Josiah Quincy, Jr., has commenced the printing of its Annals; and the title-page justly bears tribute to the memory of that Revolutionary patriot. The Observatory is situated in the midst of a generous community, and already the contributions to it, from different sources have amounted to more than 150,000 dollars, of which sum, 100,000 dollars were bequeathed by Edward Bromfield Phillips, 10,600 the gift of David Sears, Esq., and 10,000 through the will of Mr. Quincy. This *first* part of the opening volume is appropriately occupied with a History and Description of the Astronomical Observatory, illustrated by wood-cuts, by William Cranch Bond, A.M., Director of the Observatory. Among the topics, the description and figures of the Electro-recording apparatus are of special interest and importance. The *second* part which was issued last year, comprises a catalogue of fundamental stars, and of five thousand five hundred stars down to the eleventh magnitude, with some of the twelfth magnitude situated between the parallels of 0° and 0° 20′ of north declination.

19. *Manual of Blowpipe Analysis*, for the use of Students; by William Elderhorst, Prof. Chem. in the Rensselaer Polytechnic Institute. 78 pp. 12mo, New York, 1856, G. P. Putnam & Co.—The student in Mineralogy will find this a convenient and useful manual. It takes up the subject in a clear and systematic manner, describing the apparatus and reagents, and modes of blowpipe analysis, and giving briefly the reactions of the principal elements, and of the more common ores of the metals. There are also tables of reactions to facilitate further the blowpipe analysis of minerals.

J. W. Foster: *Report on the Mineral Resources of the Illinois Central Railroad*, made at the request of the President. March 4th, 1856. 30 pp. 8vo, with a plate of sections illustrating the coal fields of Southern Illinois. New York, 1856.

Agricultural Progress, considered with special reference to New Brunswick. Printed by the New Brunswick Society for the Encouragement of Agriculture, Home Manufactures and Commerce. 64 pp. 8vo, 1856.

J. Barnard Davis and J. Thurnam: *Crania Britannica:* Delineations and Descriptions of the Skulls of the early inhabitants of the British Islands, together with notices of their other remains. Decade I, fol. 76 pp. with 12 plates, and wood-cuts in the text. London, 1856.

W. Smith: *A Synopsis of the British Diatomaceæ*, with remarks on their structure. 2 vols. roy. 8vo. London, 1856.

P. Delamotte: *The Practice of Photography:* a Manual for students and amateurs, with a Calotype Frontispiece. 3d edit. revised. 12mo. London, 1856.

R. Howlett: *On the various methods of printing photographic pictures on paper,* with suggestions for their preservation. 12mo. London, 1856.

A. Erman: *Einige Beobachtungen über die Kreideformation an der Nordküste von Spanien.* 16 pp. 8vo, with a plate of fossils; from the Zeitschr. d. deutschen geol. Gesellschaft, 1854.

R. Wolf: *Ueber den Ozongehalt der Luft und seinen Zusammenhang mit der Mortalitat,* with a plate. Bern. Mitheil. March, 1855.

E. d'Eichwald: *Lethæa Rossica, or, Palæontology of Russia.* 8vo. Stuttgart. IVth number, Flora of the Palæozoic, 17¼ leaves, 268 pp. with 23 lithogr. plates, 4to.

H. Bach: *Geognostiche Uebersichtskarte von Deutschland, der Schweiz, und den angrenzenden Ländertheilen.* General Geological Chart of Germany, Switzerland and the adjoining countries, after the large maps of E. de Billy, L. v. Buch, E. de Beaumont, B. Cotta, etc., and additional observations. 9 lithochr. charts in folio with 15 pages of text. Gotha, 1855.

H. Burmeister: *Systematische Uebersicht der Thiere Brasiliens.* 2 Thl. Vogel. Hft 3. Berlin, 1856. 8vo, pp. 321—426.

J. F. J. Schmidt: *Das Zodiacallicht.* Uebersicht der seitherigen Forschungen nebst neuen Beobachtungen über die Erscheinung in den Jahren 1843–1855. 8vo. 111 pp. Braunschweig.

H. v. Sydow: *Oro-hydrographischer Atlas.* 25 Boden- und Gewässer-Karten über alle Theile der Erde. Folio. Gotha.

D'Archiac: *Histoire des Progrès de la Geologie de* 1834 à 1855. Volume VI. of this most valuable work has recently been issued. It takes up the first part of the Jurassic formation.—Price for the volume at Bailliere's, New York, $2,00.

A. Moreau de Jonnès: *Statistique de l'Industrie de la France.* 8vo, xxiv and 380 pp. Paris, 1856.

G. A. Chatin: *Anatomie Comparée des Végétaux;* Comprenant (1) les Plantes Aquatiques; (2) les Plantes Aeriennes; (3) les Plantes Parasites; (4) les Plantes Terrestres. 2nd and 3d Livraisons. 4to. Paris, 1856. Will be completed in about 20 numbers, each containing 3 leaves of text and 10 plates.

E. Cosson: *Rapport sur un Voyage Botanique en Algerie,* de Philippeville a Biskra et dans les Montes Aures, entrepris en 1853. 8vo, avec un planche. Paris, 1856.

Archives du Museum d'Histoire Naturelle. 8th volume, 4to, with 34 plates. Paris, 1856.—One volume is issued annually.

M. Roret: *Nouveau Manuel Complet du fabricant d'Etoffes* imprimées et du fabricant des papiers peints, par L. S. le Normand. 18mo. Paris, 1856.—Also other works on related subjects.

Pelouze et Fremy: *Traité de Chimie Generale,* comprenant les applications de cette science à l'Analyse Chimique, à l'Industrie, à l'Agriculture, et à l'Histoire Naturelle. 2me edit. Tome 5. Paris, 1856.—Another volume will complete the work.

M. A. Becquerel: *Des Applications de l'électricité à la Pathologie.* 8vo. Paris, 1856.

F. Malaguti: *Leçons de Chimie Agricole professées en* 1847. 18mo. Paris, 1856.

Proceedings Bost. Soc. Nat. History, Vol. V, July, 1856.—Page 337, On a factitious product alleged to have been taken from the jaw of the Musk Ox; *J. Wyman.*—p. 338, Note on two Fungi, *Spilocæa fructigena* and *Asteroma pomigena; C. J. Sprague.*—p. 339, Analyses of Serpentine Rock; *A. A. Hayes,* followed by remarks by *C. T. Jackson* and *W. B. Rogers.*—p. 349, On the Monks Island Guano; *A. A. Hayes.*—p. 355, Narraganset artificial fish-guano; *C. T. Jackson.*—p. 359, Death of Dr. Warren.—p. 363, Appointment of officers for the ensuing year: C. T. Jackson, M.D. and D. Humphreys Storer, M.D., Vice Presidents; S. L. Abbott, M.D., Corresponding Secretary; B. S. Shaw, M.D., Recording Secretary; N. B. Shurtleff, M.D., Treasurer; C. K. Dillaway, Librarian.—p. 364, Origin of Greensand and its formation in the oceans of the present epoch; *J. W. Bailey.*

Proceedings of the American Phil. Soc. Philadelphia. Vol. VI. Jan.—June, 1856, No. 55.—p. 167, Officers for the year: A. D. Bache, President, J. K. Kane, R. Dunglison, J. F. Frazer, Vice Presidents, C. B. Trego, E. O. Kendall, F. Fraley, J. L. LeConte, Secretaries.—p. 169, Improved carpenter's square; *Rev. Dr. Rogers.*—p. 179, Skater's reel; *Peale.*—p. 184, New specimens in the U. S. Mint; *DuBois.*—p. 186, Plants of the Arctic; *Durand.*—p. 189, Monks Island Guano; *A. S. Piggot.*—p. 193, 201, Apparatus for taking specific gravities; *Eckfeldt* and *Dubois.*

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GENERAL INDEX

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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XXIV.—*On American Geological History*:—Address before the American Association for the Advancement of Science, August, 1855, by JAMES D. DANA.

[IN republishing this address, the author has added various notes in illustration of the text. The circumstances of the occasion on which it was delivered precluded the introduction of detailed explanations. Moreover, as the author aimed to give the history of principles or the grander steps of progress in American geology, rather than a full exhibition of its successive discoveries, he unavoidably omitted the mention of many names which are honorably associated with the science in this country. Both obligations to others as well as himself and the science, have therefore prompted the introduction of the notes.

New Haven, September 10, 1856.]

* * * * * * *

In selecting a topic for this occasion, I have not been without perplexity. Before an Association for the Advancement of Science,—science in its wide range,—a discourse on the progress of science in America for the past year would seem legitimate. Yet it is a fact that the original memoirs in most departments, published within that period, would make a very meagre list. Moreover, it is too much to expect of any one to roam over others' territories, lest he ignorantly gather for you noxious weeds. I have, therefore, chosen to confine myself to a single topic, that

of Geology; and I propose, instead of simply reviewing recent geological papers, to restrict myself to some of the general conclusions that flow from the researches of American geologists, and the bearing of the facts or conclusions on geological science. I shall touch briefly on the several topics, as it is a subject that would more easily be brought into the compass of six hours than one. In drawing conclusions among conflicting opinions, or on points where no opinion has been expressed, I shall endeavor to treat the subject and the views of others in all fairness, and shall be satisfied if those who differ from me shall acknowledge that I have honestly sought the truth.

In the first place, we should have a clear apprehension of the intent or aim of Geological Science. It has been often said, that Geology is a *history*, the records of which are written in the rocks: and such is its highest department. But is this clearly appreciated? If so, why do we find text-books, even the one highest in authority in the English language, written back end foremost,—like a History of England commencing with the reign of Victoria. In history, the phases of every age are deeply rooted in the preceding, and intimately dependent on the whole past. There is a literal unfolding of events as time moves on, and this is eminently true of Geology.

Geology is not simply the science of rocks, for rocks are but incidents in the earth's history, and may or may not have been the same in distant places. It has its more exalted end,—even the study of the progress of life from its earliest dawn to the appearance of man; and instead of saying that fossils are of use to determine rocks, we should rather say that the rocks are of use for the display of the succession of fossils. Both statements are correct; but the latter is the fundamental truth in the science.

From the progress of life, geological time derives its division into Ages, as has been so beautifully exhibited by Agassiz. The successive phases in the progress of life are the great steps in the earth's history. What if in one country the rocks make a consecutive series without any marked interruption between two of these great ages, while there is a break or convenient starting-point in another; does this alter the actuality of the ages? It is only like a book without chapters in one case, and with arbitrary sections in another. Again, what if the events characteristic of an age—that is, in Geology, the races of plants or animals—appear to some extent in the preceding and following ages, so that they thus blend with one another? It is but an illustration of the principle just stated, that *time is one*. Ages have their progressive development, flowing partly out of earlier time, and casting their lights and shadows into the far future. We distinguish the ages by the culmination of their grand characteristics, as we would mark a wave by its crest.

Divisions of time *subordinate* to the great ages will necessarily depend on revolutions in the earth's surface, marked by abrupt transitions, either in the organic remains of the region, or in the succession of rocks. Such divisions are not universal. Each continent has its own periods and epochs, and the geologists of New York and the other States have wisely recognized this fact, disregarding European *stages* or subdivisions. This is as true a principle for the Cretaceous and Tertiary, as for the Silurian and Devonian. The usurpation of Cromwell made an epoch in English annals; not in the French or Chinese. We should study most carefully the records, before admitting that any physical event in America was contemporaneous with a similar one in Europe. The unity in geological history is in the progress of life and in the great physical causes of change, not in the succession of rocks.

The geological ages, as laid down by Agassiz, are the following:—I. The AGE OF FISHES, including the Silurian and Devonian; II. The AGE OF REPTILES, embracing from the Carboniferous through the Cretaceous; III. The AGE OF MAMMALS, the Tertiary and Post-tertiary; IV. The AGE OF MAN, or the recent era;—*fishes* being regarded as the highest and characterisic race of the first age; *reptiles* of the second; and *mammals* of the third.

More recent researches abroad, and also the investigations of Prof. Hall in this country, have shown that the supposed fish remains of the Silurian are probably fragments of Crustacea, if we except those of certain beds near the top of the Silurian; and hence the *Age of Fishes* properly begins with the Devonian. What then is the Silurian? It is pre-eminently the AGE OF MOLLUSKS.

Unlike the other two Invertebrate sub-kingdoms, the *Radiate* and *Articulate*, which also appear in the earliest fossiliferous beds, the *Molluscan* sub-kingdom is brought out in all its grander divisions. There is not simply the type, but the type analyzed or unfolded into its several departments, from the Brachiopods and Bryozoa up to the highest group of all, the Cephalopods. And among these Cephalopods, although they may have been inferior in grade to some of later periods, there were species of gigantic size, the shell reaching a length of ten or twelve feet. The Silurian is therefore most appropriately styled the *Molluscan Age*.

The Palæozoic Trilobites belong to the lower tribe of Crustacea, and Crustacea rank low among Articulates. Moreover, Crustacea (and the Articulata in general) did not reach their fullest development until the Human Era.

The Radiata were well represented in the Silurian periods; but, while inferior to the Mollusca as a sub-kingdom, only corals

and crinoids, the lower fixed or vegetative species, with rare exceptions, occur in the Silurian or Molluscan Age.

The Articulata and Radiata thus begin early, but with only the lower forms in each, and neither is a leading class in any age.

Viewing the history, then, *zoölogically*, the ages are—the Age of Mollusks, of Fishes, of Reptiles, of Mammals, of Man.

We may now change the point of view to the Vegetable Kingdom. The ages thence indicated would be three:—

I. The *Age of Algæ*, or marine plants, corresponding to the Silurian and Devonian.

II. The *Age of Acrogens*, or flowerless trees, that is, the Lepidodendra, Sigillariæ, and Calamites,—corresponding to the Coal Period and Permian; a name first proposed by Brongniart, and which may still be retained, as it is far from certain that the Sigillariæ and Calamites are most nearly related to the Coniferæ.

III. The *Age of Angiosperms*, or our common trees, like the Oak, Elm, &c., beginning with the Tertiary.

The interval between the second and third of these ages is occupied mainly by Coniferæ, the Pine tribe, and Cycadeæ, the true Gymnosperms, species of which were abundant in the Coal Period, and have continued common ever since. The Coniferæ, in the simplicity of their flowers and their naked seeds, are next akin to the Acrogens or flowerles trees. Although in the main a flowerless vegetation, for the few supposed remains of flowers observed abroad have been recently referred to undeveloped leaf-buds, it appears probable from the observations of Dr. Newberry, that there were some true flowers over the Ohio prairies,—apparently monocotyledonous, and related to the Lily tribe. But no traces of Palms or monocotyledonous trees have been found in the coal fields of this country.

Combining the results from the animal and vegetable kingdoms, we should introduce the Age of Acrogens, for the Coal Period and Permian, between the Age of Fishes and Age of Reptiles,—a space in time zoölogically occupied by the overlapping of these two ages.*

* This Age, would perhaps be more correctly styled, the *Age of Conifers*, as Conifers, a higher group than Acrogens, were among the earliest of all land plants, occurring in the upper Devonian as well as Carboniferous; and the ages in other cases are named from the superior group of species. Yet as the Acrogens were especially characteristic of the era, and the Conifers have their fullest development in the present age, the name above given seems to be preferable:—unless it prove true that the Sigillariæ and Calamites are actually related to the Coniferæ as urged by Brongniart. *Zoologically*, the age has some title to the name, *Age of Amphibians*. But before it closed, true reptiles had appeared. It is a significant fact that the Amphibians in some cases appear to have approached true reptiles, as much as some of the genera of Acrogens the Conifers. An interesting example of this, from the coal formation of Ohio, has recently been mentioned by Dr. J. Wyman, (Tenth Meeting Amer. Assoc. at Albany).

The order then reads, the Age of MOLLUSKS, of FISHES, of ACROGENS or Coal plants, of REPTILES, of MAMMALS, of MAN.

The limits of these ages are as distinct as history admits of; their blendings where they join, and the incipient appearance of a type before the age it afterwards characterizes fully opens, are in accordance with principles already explained.

The reality of progress from lower to higher forms is not more strongly marked in these names, properly applied, than in the rocks. If, hereafter, mammals, reptiles, or fishes, are found a little lower than now known, it will be changing but a sentence in the history,—not the grand idea which pervades it.

A theory lately broached by one whose recent death has caused universal grief to science, supposes that the Reptilian was an age of diminished life, between the two extremes in time, the Palæozoic and Mammalian Ages. But, in fact, two grand divisions of animals, the Molluscan and Reptilian, at this time reach their climax and begin their decline, and this is the earliest instance of the highest culmination of a grand zoölogical type.

Preceding the Silurian or Molluscan Age, there is the AZOIC AGE, or *age without animal life.* It was so named by Murchison and De Verneuil; and was first recognized in its full importance and formally announced in this country, in the Geological Report of Messrs. Foster and Whitney, although previously admitted in an indefinite way by most geologists.*

It embraces all the lowest rocks up to the Silurian, for much of the lowest granite cannot be excluded.

The actual absence of animal life in the so-called Azoic Age in this country is rendered highly probable, as Foster and Whitney show, by the fact that many of the rocks are slates and sandstones, like fossiliferous Silurian rocks, and yet have no fossils; and moreover, the beds on this continent were uplifted and folded, and to a great extent crystallized on a vast scale, before the first Silurian layers were deposited. A grand revolution is here indicated, apparently the closing event of the early physical history of the globe.†

* Report on the Geology of the Lake Superior Land District, by J. W. Foster and J. D. Whitney, U. S. Geologists; Part II, The Iron Regions together with General Geology. Senate Executive Document, No. 4, Special Session, March, 1851. Ordered to be printed, March 13, 1851. 406 pp. 8vo, with many plates, and a large geological map and section.

† Foster and Whitney observe, (loc. cit. pp. 7, 26, 132,) that at Chippewa Island (in the Menomonee river, near 45½° N, 88° W,) the Potsdam sandstone lies on the upturned Azoic slates. At White Rapids, lower down the stream, the same sandstone rests on the tilted edges of the Azoic quartz rock. Near Presqu' Isle (not far from 46° 30′—46° 35′ N, 87° 33° W), a similar contact of the nearly horizontal Potsdam and the vertical quartz rock is seen.

The Azoic of this continent was well studied and defined at a still earlier date by the distinguished geologist of Canada, Sir William E. Logan. In his Annual

As plants may live in water too hot or impure for animals, and moreover, since all nature exemplifies the principle that the earth's surface was occupied with life as soon as fitted, and with the highest forms the conditions of the time allowed, we may reasonably infer that there may have been in Azoic times marine species and plant-infusoria, forms adapted to aid in the earth's physical history; and thus vegetation may have long preceded animal life on the globe.*

After these general remarks on the divisions of Geological time, I now propose to take up the characteristic features and succession of events in American Geology.

Report for 1846, 1847, and that for 1848, he points out several examples of the Silurian covering the contorted Azoic, and his subsequent surveys have added to the facts of this kind. They occur north of the lakes Huron and Superior, and along and to the north of the St. Lawrence. Moreover in the vicinity of the lakes just mentioned, he found the Azoic divided into two unconformable groups, a *lower*, since called by him the *Laurentian*, and an upper, the *Huronian*; the former consisting of granite, syenite, gneiss, hornblende rock, hypersthene rock, crystalline limestones, etc.; the latter of diorite, slates, white and red sandstones, conglomerates, limestones, the whole much intersected by trap and metalliferous veins containing native copper, &c., and having a thickness in some places, probably of 9000 to 12000 feet.

Sections representing the nearly horizontal Lower Silurian overlying the Azoic, as observed by him in the vicinity of the St. Lawrence northeast of Lake Champlain, are figured in the Quarterly Journal of the Geological Society of London, for 1852, pp. 203 and 206.

In the progress of the Geological Survey of New York, commencing in 1836, the fact that the crystalline rocks of Northern New York were older than the Silurian was early shown, but good sections illustrating the superpositions of the two were not given.

At the meeting of the American Association at Cincinnati in 1851, when Foster and Whitney first presented their views on the Azoic, Prof. Mather stated that he had traced the continuation of the system nearly to the sources of the Mississippi and on the waters of the St. Peters,—a region since reported on by Dr. D. D. Owen, (Geol. Survey of Wisconsin, Iowa and Minnesota, 4to, 1852); Dr. H. King contributed observations on the Azoic or iron-mountain region of Missouri, (p. 194, Amer. Assoc. Rep. 1851,) indicating the inferiority in position of these rocks to the Silurian, as had been urged by Messrs. Foster and Whitney from the investigations by Mr. Mersch under their direction; and Dr. Engelmann described related rocks in Arkansas between Little Rock and the Hot Springs.

Professors W. B. and H. D. Rogers refer to Azoic Rocks as found in the Appalachians; but no instances of the superposition of the lowest Silurian in those regions on other *non-conformable* beds have yet been published; and it is a question whether the metamorphic rocks are all related to those of New England in age, or partly of this era of metamorphism and partly Azoic.

* The evidence with respect to the existence of plants in the Azoic Age, though by no means positive, is stronger than here stated.—In the *first* place, there are *limestones* among the folded strata; and as limestones of later ages were almost wholly of organic origin, these of Azoic rocks *may* also have been so.—2nd, *Graphite* is a common mineral in some of the crystalline rocks, and graphite is known to result from the alteration by heat of the carbon of plants.—3d, The Huronian rocks, according to Mr. Logan, actually contain some small seams of anthracite.—4th, Vegetation, as it is directly or indirectly the food of animals, should necessarily have preceded animal life.—With reference to the statement in the text above, it should be noted that vegetation has been observed growing among the Geysirs of Iceland, in waters having a temperature of 180° F.; and the writer has seen a case of similar kind, on Luzon, one of the Philippines, where the temperature was 160° F. This is much beyond the limit, which the eggs of animals can endure and survive.

In the outset we are struck with the comparative simplicity of the North American continent, both in form and structure. In *outline*, it is a triangle, the simplest of mathematical figures; in *surface*, it is only a vast plain lying between two mountain ranges, one on either border, the Appalachian from Labrador to Alabama on the east, the Rocky Mountains on the west; and on its *contour* it has water, east, west, north, and south.

Observe too that its border heights are proportioned to the size of the oceans. A *lofty* chain borders the Pacific, a *low* one the narrow Atlantic, while the small Arctic sea is faced by no proper mountain range.

This principle, that the highest mountains of the continents face the largest oceans, is of wide application, and unlocks many mysteries in physical geography. South America lies between the same oceans as North America: it has its eastern low range, its western Andes; and as the oceans widen southward, the continent is there pinched up almost to a narrow mountain ridge. It differs from North America in having a large expanse of ocean, the Atlantic, on the north; and, correspondingly, it has its northern mountain ridges. The world is full of such illustrations, but I pass them by.

This simplicity of ocean boundary, of surface features, and of outline, accounts for the simplicity of geological structure in North America. We may make indeed the wider statement, that all these qualities are some way connected with the positions and extent of the oceans, they seeming to point to the conclusion, that the subsidence of the oceanic basins had determined the continental features; and that farther, both results were involved in the earth's gradual refrigeration, and consequent contraction.

America has thus the simplicity of a single evolved result. Europe, on the contrary, is a world of complexities. It is but one corner of the Oriental continent,—which includes Europe, Asia, and Africa,—and while the ocean bounds it on the north and west, continental lands inclose it on the south and east. It has ever been full of cross purposes. American strata often stretch from the Atlantic west beyond the Mississippi; and east of the Rocky Monntains, it has but one proper mountain range of later date than the Silurian. Europe is much broken up into basins, and has mountains of all ages: even the Alps and Pyrenees are as recent as the Tertiary.

This wide contrast accounts for the greater completeness or generality of American revolutions, the more abrupt limits of periods, and clearer exhibition of many geological principles.

The geological structure of this country has been made known through the combined researches of a large number of investigators. The names of MACLURE, SILLIMAN, EATON, lead off the

roll; HITCHCOCK, the Professors ROGERS, the well-known GEOLOGISTS of the NEW YORK SURVEY, also, OWEN, PERCIVAL, MORTON, CONRAD, TUOMEY, and many others, have made large contributions to the accumulating results. Yet the *system* may be said to have been mainly laid open by four sets of observers, —MORTON for the Cretaceous; CONRAD for the Tertiary; the NEW YORK GEOLOGISTS for the Palæozoic strata; and the Professors ROGERS for the Carboniferous beds and the Appalachians.

The succession of Silurian and Devonian rocks in the State of New York is the most complete in the country, and it was well for the science that its rocks were so early studied, and with such exactness of detail. The final display of the Palæontology by Mr. James Hall has given great precision to the facts, and the system has thereby become a standard of comparison for the whole country, and even for the world.

This accomplished, the Carboniferous rocks were still to be registered, and the grand problem of New England Geology solved. The Professors Rogers, in the surveys of Pennsylvania and Virginia, followed out the succession of strata from the Devonian through the Coal Period, and thus, in a general way, completed the series. And more than this, they unravelled with consummate skill the contortions among the Appalachians, bringing order out of confusion, and elucidating a principle of mountain-making which is almost universal in its application. They showed that the Silurian, Devonian, and Carboniferous strata, which were originally laid out in horizontal layers, were afterwards pressed on to the north-westward, and folded up till the folds were of mountain height, and that thus the Appalachians had their origin; and that also, by the escaping heat of those times of revolution, extensive strata were altered, or even crystallized.*

* As I have already remarked, many names are above omitted which have contributed largely to our knowledge of American Geology.

While Dr. MORTON was the first to distinguish the North American *Cretaceous* beds, and pursued his researches with great energy and skill, they have been largely studied also by LYELL in different localities on the east and south, by NICOLLET and recently SHUMARD, HAYDEN, MEEK and HALL, on the beds west of the Mississippi, by RÖMER in Texas, TUOMEY in South Carolina, H. D. ROGERS and others in New Jersey, J. W. BAILEY with reference to microscopic species, and J. LEIDY for Vertebrate Remains.

The *Tertiary* has been investigated by LYELL along both the eastern and southern border; also in different localities by MORTON, M. TUOMEY, F. S. HOLMES, C. S. HALE, I. LEA, H. D. and W. B. ROGERS, RÖMER, J. D. DANA and W. P. BLAKE for the tertiary of the Pacific coast, BAILEY for minute species, HARLAN, OWEN, MÜLLER, PROUT, LEIDY, WYMAN and GIBBES, for Vertebrate fossils; while these and many other authors have published on the *post-tertiary* deposits and organic remains.

The *Silurian* and *Devonian* systems have occupied the attention of nearly all who have written on American Geology, in the East or West, among whom, there are :—HALL, MATHER, VANUXEM, EMMONS, CONRAD, De VERNEUIL of Paris, the Professors ROGERS, Messrs. WHITNEY and FOSTER, D. D. OWEN, C. T. JACKSON, D. HOUGHTON

This key soon opened to us a knowledge of New England geology, mainly through the labors of Prof. Hall, and also of Professor H. D. Rogers, following up the survey of President Hitchcock; and now the so-called primary rocks, granite, gneiss, schists, and crystalline limestones, once regarded as the oldest crystallizations of a cooling globe, are confidently set down as for the most part no older than the Silurian, Devonian, and Carboniferous of New York and Pennsylvania.*

Let us now briefly review the succession of epochs in American geological history.

The Azoic Age ended, as was observed, in a period of extensive metamorphic action and disturbance,—in other words, in a vast revolution. At its close, some parts of the continent were left as dry land, which appear to have remained so, as a general thing, in after times; for no subsequent strata cover them. Such

of Michigan, G. Troost and lately J. M. Safford of Tennessee, J. Greene, J. Locke, C. Whittlesey, I. A. Lapham, G. C. Swallow, J. G. Norwood, B. F. Shumard, besides the investigators in Canada, Sir W. E. Logan, J. Bigsby, J. W. Dawson, T. S. Hunt and others.

The *Carboniferous* formation was early studied in many of its details by Dr. S. P. Hildreth. But the successive strata of the whole formation from the Devonian through the Subcarboniferous and Coal Measures, were first systematized by the Professors Rogers, though without yet marking out in any of their publications the subdivisions of the coal measures themselves and the characteristic fossils of each, as had been done for the Devonian and Silurian by the New York Geologists. Other researches on the coal beds have been made by R. C. Taylor and J. P. Leslie in Pennsylvania, J. Hall, D. D. Owen, and others in the states of the Mississippi valley, J. S. Newberry on the fossil plants and fishes of the Ohio coal measures, Hitchcock and C. T. Jackson on the coal beds of Rhode Island; Dawson, Lyell, Jackson, etc., on the New Brunswick and Nova Scotia beds; Lea, Wyman, Leidy, Lyell and Dawson on Reptilian and other carboniferous fossils.

The parallelism of the rock formations of the east and west has been determined mainly through the researches of Prof. Hall, who first presented his views on the subject in 1841. and continues still his investigations. The examinations of De Verneuil, besides defining the limits of our Devonian, also contributed much on this subject.

The red sandstone and trap regions of the Triassic or Jurassic period, which occur in the Connecticut valley and in other valleys parallel with the Atlantic border to the south, and also to the north beyond Nova Scotia, have been specially investigated by D. Olmsted, E. Hitchcock, J. G. Percival, Professors Rogers, E. Emmons, J. W. Dawson, C. T. Jackson, F. Alger; and as regards the vertebrate fossils, by E. Hitchcock, J. Deane, W. C. Redfield, J. H. Redfield, J. Wyman, J. Leidy, I. Lea, and Prof. Owen of London; and the plants, by the Professors Rogers, C. T. F. Bunbury, and E. Hitchcock, Jr.

* The labors of Sir W. E. Logan have thrown great light upon New England geology, and are giving a definiteness to our knowledge hitherto unattained. He is finding that some of the crystalline New England rocks which stretch north into Canada, are there uncrystalline and fossiliferous, and thus is putting the question of age beyond doubt. The Berkshire limestone has thus been determined at its northern extremity as well as in New Jersey; the calcareous mica slate of western Vermont, has been shown to be Upper Silurian in age, it being uncrystalline limestone towards Gaspé, partially metamorphic and still containing distinct traces of fossils in the valleys of the river St. François and Lake Memphremagog, and farther south becoming more crystalline as well as calcareous and losing all indications of fossils. Prof. T. S. Hunt of the Canada Survey, has brought other facts to bear on this subject.

are a region in Northern New York, others about and beyond Lake Superior, and a large territory stretching from Labrador westward, as recognized by Messrs. Foster and Whitney and Prof. Hall, and the geologists of Canada.*

The Silurian or Molluscan Age next opens. The lowest rock is a sandstone, one of the most widely spread rocks of the continent, stretching from New England and Canada south and west, and reaching beyond the Mississippi,—how far is not known. And this first leaf in the record of life is like a title page to the whole volume, long afterwards completed; for the nature of the history is here declared in a few comprehensive enunciations.

1. The rock, from its thin, even layers, and very great extent, shows the wide action of the ocean in distributing and working over the sands of which it was made; and the ocean ever afterward was the most active agency in rock-making.

2. Moreover, ripple-marks, such as are made on our present sea-shores or in shallow waters, abound in the rock, both through the east and west, and there are other evidences also of moderate depths, and of emerged land.† They all announce the wonderful fact, that even then, in that early day, when life first began to light up the globe, the continent had its existence,—not in embryo, but of full-grown extent; and the whole future record is but a working upon the same basis, and essentially within the same limits. It is true that but little of it was above the sea, but equally true that little of it was at great depths in the ocean.

3. Again, in the remains of life which appear in the earliest layers of this primal rock, three of the four great branches of the Animal Kingdom are represented,—Mollusks, Trilobites among Articulates, and Corals and Crinoids among Radiates,—a sufficient representation of life for a title-page. The New

* The Azoic lands, above the ocean at this time, recognized by Messrs. Foster and Whitney in the Report referred to, were that of the Azoic region, between Lake Superior and Hudson's Bay, that between Lake Superior and Lake Michigan, the Azoic Island of Northern New York; and the facts they state would add the Missouri iron-mountain region, and the metamorphic region of Arkansas as possibly other islands. Mr. Whitney has more recently shown that the occurrence of great masses of specular or magnetic iron is proof that the metamorphic rocks containing them are of the Azoic age or præ-Silurian.

On the Geological map of northern North America, published by Mr. Isbister in the Quarterly Journal of the Geological Society for 1855, xi, 497, the Azoic is shown to extend in a narrow band northwestward from Canada to the Arctic sea between Hudson's Bay and the Winnipeg line of small lakes.

† Other marks of shallow water alluded to are wave lines, and the oblique lamination characterising many subordinate layers in the rock,—the latter due to changing currents, like the ebb and flow of tides, or variations in tidal or other currents, or the occasional action of storm waves. This oblique lamination as well as ripple marks, occurs abundantly in the Potsdam sandstone of northern New York (Emmons's Geol. Rep. p. 104, 130); in Canada (Logan's Reports, 1851–52, p. 12 and elsewhere); south of Lake Superior (Foster and Whitney, loc. cit. p. 118); in the Upper Mississippi (Owen, Survey of Wisconsin, etc., p. 48); in Pennsylvania and Virginia (Professors H. D. and W. B. Rogers).

York beds of this rock had afforded only a few mollusks; but the investigations of Owen and others have added the remaining tribes; and this diversity of forms is confirmed by Barrande in his Bohemian researches.*

Among the genera, while the most of them were ancient forms that afterwards became extinct, and through succeeding ages thousands of other genera appeared and disappeared, the very earliest and most universal was one that now exists,—the genus *Lingula*,—thus connecting the extremes of time, and declaring most impressively the unity of creation. Mr. T. S. Hunt, of the Canada Geological Survey, recently discovered that the ancient shell had the anomalous chemical constitution of bones, being mainly phosphate of lime; and afterwards he found in a modern Lingula the very same composition,—a further announcement of the harmony between the earliest and latest events in geological history.†

This earliest sandstone,—called in New York the Potsdam sandstone,—and the associated Calciferous sand-rock, mark off the *First Period* of the Molluscan Age,—the POTSDAM PERIOD, as it may be called.‡

Next followed the TRENTON PERIOD,—a period of limestones, (the Trenton limestone among them,) equal to the earlier beds in geographical limits, and far more abundant in life, for some beds are literally shells and corals packed down in bulk; yet the species were new to the period, the former life having passed away; and even before the Trenton Period closed, there were three or four epochs of destruction of life followed by new creations. The formation of these limestone beds indicates an in-

* The *Lingula prima* and *L. antiqua* are the Mollusks referred to as occurring in the New York beds. The discoveries by Owen, in the vicinity of the Falls of the St. Croix, Minnesota, and on the Mississippi, were published by him in his Report on a *Geological Reconnoisance of the Chippewa Land District of Wisconsin and the Northern part of Iowa*, Washington (Senate Document), 1848, p. 14, and subsequently in his quarto Report on Wisconsin, &c., of 1852. The fossils he mentions in the latter work are species of *Lingula*, *Obolus*, *Orbicula*, *Orthis*, several forms of Crinoids, and large Trilobites referred mostly to the new genus *Dikelocephalus*. The species as named are, *Lingula antiqua*, *L. prima*, *L. pinnaformis* Owen, *L. ampla* Owen, *Obolus Apollinis* (?), *Orbicula prima* O., *Dikelocephalus Minnesotensis* O., *D. Miniscaencis* O., *D.* (?) *Iowensis* O., *D. granulosus* O., *D. Pepinensis* O., *Lonchacephalus Chippewaensis* O., *Crepicephalus* (?) *Wisconsensis* O., *C. Miniscaensis* O.,

Prof. W. B. Rogers in the last number of this Journal (p. 296), announced the discovery of the Trilobite *Paradoxides Harlani* of Green (*P. spinosus* of Barrande) in slates ten miles south of Boston, Mass., a species found by Barrande in his protozoic or earliest fossiliferous rock of Bohemia,—thus adding a new species to the American protozoic Fauna, and the largest yet discovered, the length of some of the specimens exceeding a foot. Prof. E. Emmons announces also (Meeting of Amer. Assoc. in August last, at Albany) the discovery of a large Cyathophylloid coral in the lowest fossiliferous rocks of North Carolina. **The exact age of the rock however is yet uncertain.**—See a notice beyond in this number.

† Am. Jour. Sci., [2], xvii, 235, (1854).

‡ Through the comparisons of Prof. Hall, it is now well known that the "Lower Magnesian Limestone" of the west and a sandstone with which it alternates, correspond to the Calciferous sandrock of New York.

crease in the depth of the continental seas,—an instance of the oscillation of level to which the earth's crust was almost unceasingly subject through all geological ages until the present.

After the Trenton Period, another change came over the continent, and clayey rocks or shales were formed in thick deposits in New York, and south,—the Utica slate and Hudson River shales,—while limestones were continued in the West. This is the HUDSON PERIOD; and with it, the *Lower Silurian* closed.*

The seas were then swept of their life again, and an abrupt transition took place both in species and rocks. A conglomerate covered a large part of New York and the States south, its coarse material evidence of an epoch of violence and catastrophe: and with this deposit the *Upper Silurian* began.

The Upper Silurian has also its three great periods,—the NIAGARA, the ONONDAGA, and the LOWER HELDERBERG, besides many subordinate epochs,—each characterized by its peculiar organic remains,—each evidence of the nearly or quite universal devastation that preceded it, and of the act of omnipotence that reinstated life on the globe,—each, too, bearing evidence of shallow or only moderately deep waters when they were formed; and the Onondaga Period—the period of the New York salt rocks—telling of a half-emerged continent of considerable extent.

Another devastation took place, and then opened, as De Verneuil has shown, the Devonian Age or Age of Fishes. It commenced, like the Upper Silurian, with coarse sandstones, evidence of a time of violence; these were followed by another grit rock, whose few organic remains show that life had already reappeared. Then another change,—a change evidently in depth of water,—and limestones were forming over the continent, from the Hudson far westward: the whole surface became an exuberant coral reef, far exceeding in extent, if not in brilliancy, any modern coral sea; for such was a portion, at least, of the UPPER HELDERBERG Period.

Again there was a general devastation, leaving not a trace of the former life in the wide seas; and where were coral reefs, especially in the more eastern portion of the continental seas, sandstones and shales accumulated for thousands of feet in thickness, with rarely a thin layer of limestone. Thus passed the HAMILTON, CHEMUNG and CATSKILL Periods, of the Devonian age. The life of these regions, which in some epochs was ex-

* Prof. Hall, in connection with J. D. Whitney, has recently made the important observation, that the Galena or lead-bearing limestone, which is the upper member of the Trenton group, is separated from the Niagara limestone in Iowa and Wisconsin by thick strata of Hudson River shales, giving a prolongation to these shales before unsuspected. He had previously, with Mr. Whitney, traced these shales around the north side of Lake Huron and Lake Michigan to Pointe aux Baies, and thence along Green Bay to Lake Winnebago. These shales are however partly replaced by limestone in Ohio, etc.

ceedingly profuse, was three or four times destroyed and renewed:—not renewed by a re-creation of the same species, but by others; and although mostly like the earlier in genera, yet each having characteristic marks of the period to which it belonged. And while these Devonian Periods were passing, the first land plants appeared, foretellers of the age of verdure, next to follow.

Then come vast beds of conglomerate, a natural opening of a new chapter in the record; and here it is convenient to place the beginning of the Carboniferous Age, or the Age of Acrogens. Sandstones and shales succeeded, reaching a thickness in Pennsylvania and New Jersey, according to the Professors Rogers, of thousands of feet; while in the basin of the Ohio and Mississippi, in the course of this era, the Subcarboniferous limestone was forming from immense Crinoidal plantations in the seas.*

Another extermination took place of all the beautiful life of the waters, and a conglomerate or sandstone was spread over the encrinital bed: and this introduced the true coal period of the Carboniferous Age;—for it ended in leaving the continent, which had been in long-continued oscillations, quite emerged. Over the regions where encrinites were blooming, stretch out vast wet prairies or marshes of the luxuriant coal vegetation. The old system of oscillations of the surface still continues, and many times the continent sinks to rise again,—in the sinking, extinguishing all continental life, and exposing the surface to new depositions of sandstone, clays, or limestone, over the accumulated vegetable remains; in the rise, depopulating the seas by drying them up, and preparing the soil for verdure again; or at times, convulsive movements of the crust carrying the seas over the land, leaving destruction behind. And thus, by repeated alternations, the coal period passes, some six thousand feet of rock and coal-beds being formed in Pennsylvania, and fourteen thousand feet in Nova Scotia.

I have passed on in rapid review, in order to draw attention to the series or succession of changes, instead of details.† So brief an outline may lead a mind not familiar with the subject to regard the elapsed time as short; whereas to one who follows out the various alternations and the whole order of events, the idea of *time immeasurable* becomes almost oppressive.

* This Subcarboniferous limestone is sparingly represented in Pennsylvania among the sandstones and shales; but according to Prof. W. B. Rogers it increases to the southward, and in Virginia acquires a thickness of 1500 to 2000 feet.

† The names given to the subdivisions of the Palæozoic rocks are the same that have been laid down by the New York Geologists, whose assiduous and successful labors in a territory of so great geological importance, entitle them to pronounce upon the nomenclature of American Rocks. I have varied from the ordinary use of the terms only in applying them to the periods and epochs when the rocks were formed, so as to recognize thereby the historical bearing of geological facts. The

Before continuing the review, I will mention some conclusions which are here suggested.

I. In the first place, through the periods of the Silurian and Devonian, at twelve distinct epochs at least, the seas over this American continent were swept of all or nearly all existing life, and as many times they were repeopled: and this is independent of many partial exterminations and renewals of life that at other times occurred.

If Omnipotent Power had been limited to making *monads* for after development into higher forms, many a time would the whole process have been utterly frustrated by hot water, or by mere changes of level in the earth's crust, and creation would have been at the mercy of dead forces. The surface would have required again and again the sowing of monads, and there would have been a total failure of crops after all; for these exterminations continue to occur through all geological time into the Mammalian Age.

II. Again: I have observed that the continent of North America has never been the deep ocean's bed, but a region of

Periods and Epochs thus made out are as follows—excluding minor subdivisions which may make Sub-epochs, and not attempting to give the parallel subdivisions for the West. On this subject, the volumes and papers by Prof. Hall especially should be consulted.

I. SILURIAN AGE.

1. *Lower Silurian.*

1. Potsdam Period.—1st Epoch. Potsdam sandstone: 2nd. Calciferous sandrock.
2. Trenton Period.—1st Epoch. Chazy limestone; 2nd. Birdseye; 3d. Black River; 4th. Trenton.
3. Hudson Period.—1st Epoch. Utica Shale; 2nd. Hudson River Shale. (Hudson River Shale and Blue limestone of Ohio in parts of the west.)

2. *Upper Silurian.*

1. Niagara Period.—1st Epoch. Oneida Conglomerate; 2nd. Medina Sandstone; 3d. Clinton Group; 4th. Niagara Group.
2. Onondaga Period.—1st Epoch. Galt limestone; 2nd. Onondaga Salt Group.
3. Lower Helderberg Period.—Limestones. (Statement of epochs here omitted).

II. DEVONIAN AGE.

1. Oriskany Period.—1st Epoch. Oriskany Sandstone; 2nd. Cauda-galli Grit.
2. Upper Helderberg Period.—1st Epoch. Schoharie Grit; 2nd. Upper Helderberg group.
3. Hamilton Period.—1st Epoch. Marcellus Shales; 2nd. Hamilton group; 3d. Genesee Slate.
4. Chemung Period.—1st Epoch. Portage; 2nd. Chemung group.
5. Catskill Period.—Catskill Red Sandstones and Shales. (No. IX. of Rogers.)

III. CARBONIFEROUS AGE.

1. Subcarboniferous Period.—1st Epoch, Conglomerates, Sandstones and Shales (with some coal seams); 2nd. Sandstones, Shales and Carboniferous limestone. Nos. X. and XI. of Rogers.
2. Carboniferous Period.—1st Epoch, Millstone Grit; 2nd. Lower Coal Measures; 3d. Upper Coal Measures. Nos. XII. and XIII. of Rogers.
3. Permian Period.—Probably unrepresented in Eastern North America, except by the events of the Appalachian revolution.

comparatively shallow seas, and at times emerging land; and was marked out in its great outlines even in the earliest Silurian. The same view is urged by De Verneuil, and appears now to be the prevailing opinion among American geologists. The depth at times may have been measured by the thousand feet, but not by miles.

III. During the first half of the lower Silurian era, the whole east and west were alike in being covered with the sea. In the first or Potsdam Period, the continent was just beneath or at the surface. In the next or Trenton Period, the depth was greater, giving purer waters for abundant marine life. Afterwards, the East and West were in general widely diverse in their formations; limestones, as Mr. Hall and the Professors Rogers have remarked, were generally in progress over the West, that is, the region, now the great Mississippi Valley, beyond the Appalachians, while sandstones and shales were as generally forming from northeastern New York south and southwest through Virginia. The former, therefore, has been regarded as an area of deeper waters, the latter as, in general, shallow, when not actually emerged. In fact, the region toward the Atlantic border, afterwards raised into the Appalachians, was already, even before the Lower Silurian era closed, the higher part of the land: it lay as a great reef or sand-bank, partly hemming in a vast continental lagoon, where corals, encrinites and mollusks grew in profusion, thus separating more or less perfectly the already existing Atlantic from the interior waters.

IV. The oscillations or changes of level over the continent, through the Upper Silurian and Devonian, had some reference to this border region of the continent: the formations approach or recede from it, and sometimes pass it, according to the limits of the oscillations eastward or westward. Along the course of the border itself there were deep subsidences in slow progress, as is shown by the thickness of the beds. It would require much detail to illustrate these points, and I leave them with this bare mention.

The Hudson River and Champlain valleys appear to have had their incipient origin at the epoch that closed the Lower Silurian; for while the preceding formations cross this region and continue over New England, the rocks of the Niagara and Onondaga Periods (the first two of the Upper Silurian) thin out in New York before reaching the Hudson River. Mr. Logan has recognized the division of America to the northeast into two basins by an anticlinal axis along Lake Champlain, and observes also that the disturbances began as early, at least, as the close of the Lower Silurian, mentioning, too, that there is actually a want of conformity at Gaspé between the beds of the Upper

and Lower Silurian,—another proof of the violence that closed the Lower Silurian era.*

But let us pass onward in our geological record.

All the various oscillations that were in slow movement through the Silurian, Devonian, and Carboniferous Ages, and which were increasing their frequency throughout the last, raising and dipping the land in many alternations, were premonitions of the great period of revolution,—so well elucidated, as already observed, by the Professors Rogers,—when the Atlantic border, from Labrador to Alabama, long in preparation, was at last folded up into mountains, and the Silurian, Devonian, and Carboniferous rocks were baked or crystallized. No such event had happened since the revolution closing the Azoic Period. From that time on, all the various beds of succeeding ages up to the top of the Carboniferous had been laid down in horizontal or nearly horizontal layers, over New England as well as in the West,—for the continent from New England westward, we have reason to believe, was then nearly a plain, either above or below the water; there had been no disturbances except some minor uplifts: the deposits, with small exceptions, were a single unbroken record, until this Appalachian revolution.†

This epoch, although a time of vast disturbances, is more correctly contemplated as an epoch of the slow measured movement of an agency of inconceivable power, pressing forward from the ocean towards the northwest; for the rocks were folded up without the chaotic destruction that sudden violence would have been likely to produce. Its greatest force and its earliest beginning was to the northeast. I have alluded to the disturbance

* This Eastern border of the American continent, then in process of formation over the present Appalachian region from Labrador and Canada southwestward, lay deeper to the south than to the north. In Canada and the Azoic of Northern New York, there was land out of water, forming its northern limit. From thence it stretched on with its gradually deepening waters, though varying constantly with the oscillations. The thickness of many of the sedimentary beds passing southward from the New York Azoic prove this increasing depth to have been a general fact; and it is corroborated by a statement made by Prof. W. B. Rogers (meeting of Amer. Assoc. in August last at Albany), that the subcarboniferous sandstones and shales containing but little limestone in Pennsylvania, were replaced by beds of the subcarboniferous limestone which to the south in Virginia reach a great thickness (see note to page 317)—the limestones indicating clearer and somewhat deeper waters. The early disturbances and uplifts *in the northeast* near Gaspé and along the Hudson valley also accord with this view.

Again, the position of the Azoic dry land in Canada and of the sedimentary rocks south and southwest, shows us that the Continent in those early times received the northern Labrador current,—which would have kept by the shore as now, along the eastern border of this Azoic,—over New Brunswick and Nova Scotia, and that thence its natural course would have been southwest over the Appalachian region, where the sandstones and shales were extensively accumulated; and therefore its aid in making these deposits can scarcely be doubted.

† It is urged by Prof. Hall and others that the Carboniferous beds in the west lie unconformably on the beds below. But the disturbance indicated was not one of bold flexures or uplifts.

between the Upper and Lower Silurian beds of Gaspé, to the north. Another epoch of disturbance, still more marked, preceded, according to Mr. Logan, the Carboniferous beds in those northeastern regions; and New England, while a witness to the profound character and thoroughness of the Appalachian revolution, attests also to the greater disturbance towards its northern limits. Some of the Carboniferous strata were laid down in Rhode Island as clay and sand and layers of vegetable debris: they came forth from the Appalachian fires as we now have them, the beds contorted, the coal layers a hard siliceous anthracite or even graphite in places, the argillaceous sands and clays crystallized as talcose schist, or perhaps gneiss or syenite.

These very coal-beds, so involved in the crystalline rocks, are part of the proof that the crystallization of New England took place after the Coal Era. Fossils in Maine, Vermont, Canada, and Massachusetts add to the evidence. The quiet required by the continent for the regular succession and undisturbed condition of the rocks of the Silurian, Devonian, and Carboniferous formations, shows that in neither of these ages could such vast results of metamorphic action and upheaval have taken place.

The length of time occupied by this revolution is beyond estimate. Every vestige of the ancient Carboniferous life of the continent disappeared before it. In Europe, a Permian Period passed, with its varied life; yet America, if we may trust negative evidence, still remained desolate. The Triassic Period next had its profusion of living beings in Europe, and over two thousand feet of rock; America through all, or till its later portions, was still a blank: not till near the beginning of the Jurassic Period do we find any traces of new life, or even of another rock above the Carboniferous.

What better evidence could we have than the history of the oscillations of the surface from the earliest Silurian to the close of the Carboniferous Age, and the final cresting of the series in this Appalachian revolution, that the great features of the continent had been marked out from the earliest time? Even in the Azoic, the same northeast and southwest trend may be observed in Northern New York and beyond Lake Superior, showing that, although the course of the great Azoic lands was partly east and west, the same system of dynamics that characterized succeeding ages was then to some extent apparent.

The first event in the records after the Appalachian revolution, was the gathering up of the sands and rolled fragments of the crystallized rocks and schists along the Atlantic border into beds; not over the whole surface, but in certain valleys, which lie parallel with the Appalachian chain, and which were evidently a result of the foldings of that revolution. The beds are the red sandstones and shales, which stretch on for one hundred

and twenty miles in the Connecticut valley: and similar strata occur in Southeastern New York, in New Jersey, Virginia, North Carolina and Nova Scotia. These long valleys are believed to have been estuaries, or else river courses.

The period of these deposits is regarded as the earlier Jurassic by Professor W. B. Rogers. Dr. Hitchcock supposes a portion of the preceding or Triassic Period to be represented.*

Many of the layers show, by their shrinkage cracks, ripple-marks, and footprints, as others have observed, that they were formed in shallow waters, or existed as exposed mud-flats. But they accumulated till they were over a thousand feet thick in Virginia, and in New England two or three thousand, according to the lowest estimate. Hence the land must have been sinking to a depth equal to this thickness, as the accumulation went on, since the layers were formed successively at or near the surface.

Is it not plain, then, that the oscillations, so active in the Appalachian revolution and actually constituting it, had not altogether ceased their movements, although the times were so quiet that numerous birds and reptiles were tenants of the Connecticut region? Is it not clear that these old valleys, occurring at intervals from Nova Scotia to South Carolina, originally made by foldings of the earth's crust, were still sinking?

And did not the tension below of the bending rocks finally cause ruptures? Even so: and the molten rock of the earth's interior which then escaped, through the crystalline rocks beneath and the overlying sandstone, constitutes the trap mountains, ridges, and dykes, thickly studding the Connecticut Valley, standing in palisades along the Hudson, and diversifying the features of New Jersey and parts of Virginia and North Carolina. The trap is a singularly constant attendant on the sandstone,

* This Red Sandstone, after being known for a while under the name of "Old Red Sandstone," was long called the "New Red Sandstone," it being shown to be above the carboniferous system. The first step towards a nearer determination of its age was made by Mr. J. H. Redfield in a paper on the Fossil Fishes of the Connecticut valley published in 1836, who made it Jurassic (Lias or Oolitic), (Ann. Lyc. N. Hist. N. Y., vol. iv.) Mr. W. C. Redfield added to the facts bearing on this conclusion through discoveries made in New Jersey and Virginia. Prof. W. B. Rogers deduced from the coal plants of the Richmond beds, the same age for those beds, while admitting that other beds of the sandstone might be Triassic. Afterwards on finding the same Posidonia and Cypridæ in North Carolina, in each of the belts in Virginia, in the belt in Pennsylvania near Phenixville, and one plant (Lycopodites Williamsonis) common to Virginia and Massachusetts, he suggested that all the beds were probably Jurassic (Am. J. Sci. [2], xix, 123). Mr. E. Hitchcock, Jr., detected recently a fossil plant (*Clathropteris rectinsculus*, Am. J. Sci. [2], xx, 22), near the middle of the sandstone formation in Massachusetts, and remarks that it indicates the existence of the Lower Jurassic at that place, and also renders it probable that the Triassic may be represented in the inferior beds, as is sustained by Prof. Hitchcock. Prof. Emmons has recently obtained Reptilian Fish, and Molluscan fossils in North Carolina, (communicated to the Amer. Assoc. at Albany in August last,) which are related to those of the Triassic and Jurassic periods. The amount of evidence as far as now understood therefore tends to sustain the view that the Period of the sandstone, while it may cover part of the Triassic, is mainly Jurassic.

and everywhere bears evidence of having been thrown out soon after the deposition of the sandstone, or in connection with the formation of its later beds. Even the small sandstone region of Southbury in Connecticut, has its trap.

Thus ended in fire and violence, and probably in submergence beneath the sea, the quiet plains of the Connecticut valley, where lived, as we now believe, the first birds of creation; kinds that were nameless, until, some countless ages afterwards, President Hitchcock tracked them out, found evidence that they were no unworthy representatives of the feathered tribe, and gave them and their reptile associates befitting appellations.*

Such vast regions of eruptions could not have been without effusions of hot water and steam, and copious hot springs. And may not these heated waters and vapors, rising through the crystalline rocks below, have brought up the copper ores, that are now distributed, in some places, through the sandstone? The same cause, too, may have given the prevalent red color to the rock, and produced changes in the adjoining granite.

After the era of these rocks, there is no other American record during the European Jurassic Period.

In the next or Cretaceous Period, the seas once more abound in animal life. The position of the cretaceous beds around the Atlantic border shows that the continent then stood above the sea very much as now, except at a lower level. The Mississippi valley, which, from the Silurian, had generally been the region of deeper waters, was even in cretaceous times occupied to a considerable extent by the sea,—the Mexican Gulf then reaching far north, even high up the Missouri, and covering also a considerable part of Texas and the Rocky Mountain slope.

An age later, the Cretaceous species had disappeared, and the Mammalian Age (or the Tertiary, its first Period) begins, with a wholly new Fauna, excepting, according to Professor Tuomey, some half a dozen species, about which however there is much doubt. The continent was now more elevated than in the preceding age, and the salt waters of the Mexican Gulf were withdrawn from the region of Iowa and Wisconsin, so as not to reach beyond the limits of Tennessee.†

* Mr. J. Deane of Greenfield was also an early explorer of these tracks, and is now engaged in publishing on the subject, illustrating his memoir with plates of great beauty and perfection.

† The recent investigations of F. B. Meek and Dr. J. V. Hayden, have shown (Proc. Acad. Nat. Sci. Philad., viii, 111, 1856,) that while there is much *fresh-water* tertiary in the Nebraska regions and beyond, there is also about the head waters of the Missouri some *marine* tertiary. The region investigated lies between the 46th and 49th parallels of North latitude and the 100th and 108th degrees of longitude: but it is not yet ascertained whether the body of salt water thus indicated was an isolated area, or an arm from the Mexican Gulf. The shells, (species of Ostrea, Corbula, and Cerithium) do not satisfactorily fix the age of the tertiary, but suggest, the authors say, that it may be the older Eocene. They occur in the same beds with

Two or three times in the course of the Tertiary Period, the life of the seas was exterminated, so that the fossils of the later Tertiary are not identical with any in the earliest beds,—excluding some fish remains, species not confined to the coast waters. The crust of the earth was still oscillating; for the close of the first Tertiary epoch was a time of subsidence; but the oscillation or change of level was slight, and by the end of the Tertiary, the continent on the east stood within a few feet of its present elevation, while the Gulf of Mexico was reduced nearly to its present limits.*

I have thus brought this rapid sketch to the close of the Tertiary, having omitted much of great interest, in order to direct attention to the one grand fact,—that the continent from the Potsdam sandstone, or before, to the Upper Tertiary, was one in its progress,—a single consecutive series of events according to a common law. It is seen, that the great system of oscillations, due to force pressing or acting from the southeast, which reached its climax in the rise of the Appalachians, then commenced a decline. We mark these oscillations still producing great results in the Jurassic Period along the whole eastern border from Nova Scotia to the Carolinas. Less effect appears in the Cretaceous Period; and gradually they almost die out as the Tertiary closes, leaving the Mississippi Valley and the eastern shores near their present level.

Thus were the great features of Middle and Eastern North America evolved; nearly all its grand physical events, including its devastations and the alternations in its rocks, were consequent upon this system of development. Moreover, as I have observed, this system was some way connected with the relative position of the continent and the oceanic basin.

We need yet more definite knowledge of the Pacific border of North America to complete this subject. It is in accordance with the fact that the highest mountains are there, that volcanoes have been there in action; and also that, in the Tertiary Period, elevations of one to two thousand feet took place; and that immediately before the Tertiary, a still greater elevation of the Rocky Mountains across from east to west occurred. The system of changes between the Rocky Mountains and the Pacific has been on a grander scale than on the Atlantic border, and also from a different direction,—and this last is an element for

numerous freshwater shells, species of Melania, Physa, Paludina, Cyrena, and all are such kinds as inhabit fresh and brackish waters. The tertiary deposits of the Bad Lands, or that part where the bones occur, have afforded no evidence of salt water origin; and the same is true of the Lignite beds of the far north. While therefore the tertiary beds are extensive, the marine tertiary, indicating the presence of the sea, as far as present knowledge goes, is quite limited.

* Naming the North American Tertiary Epochs from prominent localities, as in the Palæozoic, they are:—1. The Claiborne, or Older Eocene; 2. The Vicksburg, or Newer Eocene; 3. The Yorktown, or Pliocene and Miocene in one.

whose influence on the general features we cannot yet make full allowance.

Through all this time, central British America appears to have taken little part in the operations; and what changes there were, except it may be, in the Arctic regions, conformed to the system prevailing farther south, for the rocks of the Jurassic Age, like the Connecticut River sandstone, are found as far north as Prince Edward's Island, in the Gulf of St. Lawrence.

But the Tertiary Period does not close the history of the continent. There is another long Period the Post-tertiary,—the period of the Drift, of the Mastodon and Elephant, of the lake and river terraces, of the marine beds on Lake Champlain and the St. Lawrence,—all anterior to the Human Era.

From this time there is a fundamental change in the course of operations. The oscillations are from the north, and no longer from the southeast.

The *drift* is the first great event, as it underlies the other loose material of the surface; and all recognize it as a *northern* phenomenon, connected with northern oscillations.

The upper terrace of the lakes and rivers, and also the marine beds four hundred feet above the level of Lake Champlain, and five hundred above the St. Lawrence, which have been called Laurentian deposits, are marks of a *northern* depression, as no one denies.

The subsequent elevation to the present level again, by stages marked in the lower river terraces, was also *northern*, affecting the region before depressed.

The south felt but slightly these oscillations.

There are thus the following epochs in the Post-tertiary:—the *Drift Epoch;* the *Laurentian Epoch*, an epoch of depression; the *Terrace Epoch*, an epoch of elevation; *three* in number, unless the Drift and Laurentian Epochs are one and the same.

As this particular point is one of much interest in American Geology, I will briefly review some of the facts connected with the drift.

The drift was one of the most stupendous events in geological history. In some way, by a cause as wide as the continent,—and, I may say, as wide nearly as the world,—stones of all sizes, to immense boulders of one or two thousand tons weight, were transported, along with gravel and sand, over hills and valleys, deeply scratching the rocks across which they travelled. Although the ocean had full play in the many earlier ages, and an uneasy earth at times must have produced great convulsions, in no rock strata, from the first to the last, do we find imbedded stones or boulders at all comparable in magnitude with the immense blocks that were lifted and borne along for miles in the Drift epoch.

Much doubt must remain about the origin of the drift, until the courses of the stones and scratches about mountain ridges and valleys shall have been exactly ascertained. The general course from the north is admitted; but the special facts proving or disproving a degree of dependence on the configuration of the land have not yet been sufficiently studied.

One theory, the most prevalent, supposes a deep submergence over New England and the North and West, even to a depth of four or five thousand feet, and conceives of icebergs as floating along the blocks of stone, and at bottom scratching the rocks. Another, that of the Professors Rogers, objects to such a submergence, and attributes the result to an incursion of the ocean from the north, in consequence of an earthquake movement beneath the Arctic Seas.

The idea of a submergence is objected to on the ground that the sea has left no proof of its presence by fossils, sea-shore terraces or beaches.

Unless the whole continent were submerged, of which there is no evidence whatever, there must have been in the Post-tertiary Period an east-and-west line of sea-shore, say across New Jersey, Pennsylvania, Southern Ohio, and the other States west, or still farther south; and yet no such sea-shore marks now exist to trace its outline, although the ocean must have been a portion of the same that had laid up the Cretaceous and Tertiary beds all along the coasts, and, in fact, already contained the oysters and clams and many other species of Mollusks which now exist. Can it be, that, contrary to all the ways of the past, such a grand submergence as this view supposes, placing New England four thousand feet under water, could have transpired without a sea-shore record?

Very many have replied in the affirmative; and one able advocate of this view, who sees no difficulty in the total absence of sea-shore terraces or fossils at all levels above the Laurentian beds, finds in the succeeding epoch sea-shore accumulations in all the terraces of our rivers. Why this wonderful contrast? What withheld the waves from acting like waves in the former case, and gave unbounded license in the latter?

This much, then, seems plain, that the evidence although negative, is very much like positive proof that the land was not beneath the sea to the extent the explanation of the drift phenomena would require.

There are other objections to this view of submergence. If North America were submerged from the southern boundary-line of the drift far into the Arctic regions, this would have made a much warmer climate for the continent than now; if only half-way, then there is another east-and-west shore line to be traced out, before the fact of the submergence can be admitted. Again,

we know how the ice, while a glacier, or along a shore of cliffs, (for all bergs are believed to have once been glaciers,) may receive upon them or gather up heavy blocks of stone, even a thousand tons in weight, and bear them off to distant regions, as now happens in the Northern Atlantic. But we have no reason to believe that the massy foot of a berg could pick up such blocks and carry them twenty miles, to drop them again: and hence the short distance of travel would prove that the bergs were made that short distance to the north, and this implies the existence there of glacier valleys and requires a glacier theory.

But without considering other difficulties, I pass to the inquiry, Whether the lands, if not submerged, were at any higher level than now?

There is evidence of striking character, that the regions or coasts over the higher latitudes, in both the northern and southern hemispheres, were once much elevated above their present condition. The *fiords*, or deep coast channels, scores of miles long, that cut up the coast of Norway and Britain, of Maine, Nova Scotia and Greenland, of Western America from Puget's Sound north, of Southern South America from Chiloe south, of Van Diemen's Land and other southern islands, are all valleys that could not have been scooped out when filled with the ocean's waters as now; that could have been formed only when the land in those high latitudes, north and south, was elevated till their profound depths were nearly or quite dry. Whether this elevation was in the period of the Post-tertiary has not been precisely ascertained. But as they are proof of a north-and-south system of oscillations, the same that was in action in the Drift epoch, and as the cold that such a change would occasion is not very distinctly apparent in the Tertiary period, and much less in the earlier, we have reason for referring the greater part of the elevation to that Drift era, and for believing that the excavation of these fiord valleys was then in progress. Both fiords and drift are alike high-latitude phenomena on all the continents north and south. The change of climate between the Cretaceous and Tertiary, and the absence of Tertiary beds north of Cape Cod, may have been connected with an incipent stage in this high-latitude movement.

However this be, there is other evidence in the cold of the Drift period, of some extraordinary cause of cold. The drift in Europe and Britain is generally attributed to glaciers and icebergs during a period of greater cold than now; and the fact of this greater cold is so generally admitted, that it is common to speak of it as the glacial period. Professor Agassiz, moreover, has urged for this continent the glacial theory.

In a memoir of great research by Mr. Hopkins of Cambridge, England, the able author maintains that this glacial cold might

have been produced over Europe, partly at least, by a diversion of the Gulf Stream from its present position. He seems in his paper to attribute too much effect to the Gulf Stream, and too little to the prevailing currents of the atmosphere. But, setting this aside, it is unfortunate for the hypothesis, that there is no reason to suppose that America was not then as much in the way of such a diversion as now. The small changes of level which the Tertiary and Post-tertiary beds of the Gulf have undergone, prove that the gate of Darien was early closed, and has since continued closed. America, as facts show, has not been submerged since the Tertiary to receive the stream over its surface. If it had been, it would have given other limits to her own drift phenomena; for it is an important fact that these limits in America and Europe show the very same difference in the climates or in the isothermals as that which now exists.*

On the question of the drift, we therefore seem to be forced to conclude, whatever the difficulties we may encounter from the conclusion, that the continent was not submerged, and therefore that icebergs could not have been the main drift agents: that the period was a cold or glacial epoch, and the increase of cold was probably produced by an increase in the extent and elevation of northern lands. Further than this, in the explanation of the drift, known facts hardly warrant our going.

If, then, the Drift epoch was a period of elevation, it must have been followed by a deep submergence to bring about the depression of the continent already alluded to, when the ocean stood four hundred feet deep in Lake Champlain, and a whale—for his bones have been found by the Rev. Z. Thompson of Burlington—was actually stranded on its shores; and when the upper terrace of the rivers was the lower river flat of the valleys. This submergence, judging from the elevated sea-beaches and terraces, was five hundred feet on the St. Lawrence and Lake Champlain; eighty feet at Augusta, Maine; fifty feet at Lubec; thirty at Sancoti Head, Nantucket; over one hundred at Brooklyn, N. Y.; and two hundred to two hundred and fifty in Central New England, just north of Massachusetts; while south, in South Carolina, it was but eight or ten feet.

But whence the waters to flood valleys so wide, and produce the great alluvial plain constituting the upper terrace, so immensely beyond the capability of the present streams? Perhaps, as has been suggested for the other continent, and by Agassiz for

* Moreover, the Gulf Stream is known to be a deep current, so deep as to be turned around to the northward in part by the submarine slopes of the outer West Indian Islands, and it would have required a submergence of many hundred feet, and moreover a passage quite across the continent into the Arctic seas, to have given the stream a chance over the land: and even then, if the West Indian Islands were not also deeply sunk in the ocean, a large part of the current would still have kept its present track in the Atlantic.

this, from the melting snows of the declining glacier epoch. The frequent absence of fine stratification, so common in the material of this upper terrace, has often been attributed to a glacier origin.

According to this view, the events of the Post-tertiary Period in this country make a single consecutive series, dependent mainly on polar or high-latitude oscillations:—an elevation for the *first* or *Glacial Epoch;* a depression for the *second* or *Laurentian Epoch;* a moderate elevation again, to the present height, for the *third* or *Terrace Epoch.*

The same system may, I believe, be detected in Europe; but, like all the geology of that continent, it is complicated by many conflicting results and local exceptions; while North America, as I have said, is like a single unfolding flower in its system of evolutions.

There is the grandeur of nature in the simplicity to which we thus reduce the historical progress of this continent. The prolonged oscillations of the crust, caused by pressure from the southeast beneath the Atlantic, which reach on through the Palæozoic ages, producing the many changes of level in the Silurian and Devonian, still others of greater frequency in the Carboniferous, and then, as in an outburst of long emprisoned energy, throwing up the range of the Appalachians, with vast effusions of heat through the racked and tortured crust, next go on declining as the Jurassic and Cretaceous Periods pass, and finally fade out in the Tertiary. The northern oscillations, perhaps before in progress, then begin to exhibit their effects over the high temperate latitudes, and continue to the Human Era. The sinking of Greenland, now going on, may be another turn in the movement; and it is a significant fact, that, while we have both there and in Sweden northern changes of level in progress, such great secular movements have nowhere been detected on the tropical parts of the continents.

In deducing these conclusions, I have only stated in order the facts as developed by our geologists. Were there time for a more minute survey of details, the results would stand forth in bolder characters.

The sublimity of these continental movements is greatly enhanced when we extend our vision beyond this continent to other parts of the world. It can be no fortunate coincidence, that has produced the parallelism between the Appalachian system and the grand feature lines of Britain, Norway, and Brazil, or that has covered the north and south alike with drift and fiords. But I will not wander, although the field of study is a tempting one.

In thus tracing out the fact, that there has been a plan or system of development in the history of this planet, do we separate

the Infinite Creator from his works? Far from it: no more than in tracing the history of a plant. We but study the method in which Boundless Wisdom has chosen to act in creation. For we cannot conceive that to act without plan or order is either a mark of divinity or wisdom. Assuredly it is far from the method of the God of the universe, who has filled all nature with harmonies; and who has exhibited his will and exalted purpose as much in the formation of a continent, to all its details, as in the ordered evolution of a human being. And if man, from studying physical nature, begins to see only a Deity of physical attributes, of mere power and mathematics, he has but to look within at the combination of the affections with intellect, and observe the latter reaching its highest exaltation when the former are supreme, to discover proofs that the highest glory of the Creator consists in the infinitude of his love.

My plan, laid out in view of the limited time of a single address, has led me to pass in silence many points that seem to demand attention or criticism; and also to leave unnoticed the labors of many successful investigators.

There are some subjects, however, which bear on general geology, that should pass in brief review.

I. The rock-formations in America may in general be shown to be synchronous approximately with beds in the European series. But it is more difficult to prove that catastrophes were synchronous, that is, revolutions limiting the ages or periods.

The revolution closing the Azoic Age, the *first* we distinctly observe in America, was probably nearly universal over the globe.

An epoch of some disturbance between the Lower and Upper Silurian is recognized on both continents. Yet it was less complete in the destruction of life on Europe than here, more species there surviving the catastrophe; and in this country there was but little displacement of the rocks.

The Silurian and the Devonian Ages each closed in America with no greater revolutions than those minor movements which divided the subordinate periods in those ages. Prof. Hall observes that they blend with one another, and the latter also with the Carboniferous, and that there is no proof of contemporaneous catastrophes giving them like limits here and in Europe.

But after the Carboniferous, came the Appalachian revolution, one of the most general periods of catastrophe and metamorphism in the earth's history. Yet in Europe the disturbances were far less general than with us, and occurred along at the beginning and end of the Permian Period.

From this epoch to the close of the Cretaceous, there were no contemporaneous revolutions, as far as we can discover. But the Cretaceous Period terminates in an epoch of catastrophe which was the most universal on record, all foreign Cretaceous species having been exterminated, and all American, with a few doubtful exceptions.* This third general revolution was the prelude to the Mammalian Age. But there is no time to do this subject justice, and I pass on,—merely adding, on account of its interest to those who would understand the first chapter of Genesis, that there is no evidence whatever in Geology, that the earth, after its completion, passed through a chaos and a six days' creation at the epoch immediately preceding man, as Buckland, in the younger days of the science, suggested, on *Biblical*, not on Geological, ground. No one pretends that there is a fact or hint in Geology to sustain such an idea: on the contrary, it is utterly opposed to it.

II. The question of the existence of a distinct *Cambrian system* is decided adversely by the American records. The Mollusca in all their grand divisions appear in the subdivisions of the Lower as well as Upper Silurian, and the whole is equally and alike the Molluscan or Silurian Age. The term Cambrian, therefore, if used for fossiliferous strata, must be made subordinate to Silurian.

The *Taconic system* of Emmons has been supposed by its author to have a place inferior to the Cambrian of Sedgwick, or else on a level with it. But the investigations of Hall, Mather, and Rogers, and more lately of Logan and Hunt, have shown that the Taconic slates belong with the upper part of the Lower Silurian, being, in fact, the Hudson River shales, far from the bottom of the scale.

III. The American rocks throw much light on the origin of coal. Professor Henry D. Rogers, in an able paper on the American coal-fields, has well shown that the condition of a delta or estuary for the growth of the coal-plants, admitted even now by some eminent geologists, is out of the question, unless the whole continent may be so called; for a large part of its surface was covered with the vegetation. Deltas exist where there are large rivers; and such rivers accumulate and flow where there are mountains. How, then, could there have been rivers, or true deltas of much size, in the Coal Period, before the Rocky Mountains or Appalachians were raised? It takes the Andes to make an Amazon. This remark has a wider application than simply to the Coal Era.

IV. In this connection, I add a word on the idea that the rocks of our continent have been supplied with sands and gravel from

* This catastrophe may not have been violent; it may have been ages in accomplishment; yet it was disastrous to the living tribes over the whole sphere.

a continent now sunk in the ocean. No facts prove that such a continent has ever existed, and the whole system of progress, as I have explained, is opposed to it. Moreover, gravel and sands are never drifted away from sea-shores, except by the very largest of rivers, like the Amazon; and with these, only part of the lightest or finest detritus is carried far away; for much the larger part is returned to the coast through tidal action, which has a propelling movement shoreward, where there are soundings. The existence of an Amazon on any such Atlantic continent in Silurian, Devonian, or Carboniferous times, is too wild an hypothesis for a moment's indulgence.

V. The bearings of the facts in American Palæontology on the science, might well occupy another full discourse. I will close with brief allusions to some points of general interest.

1. The change in the Fauna of the globe as the Age of Man approaches, is one of the most interesting facts in the earth's history. It was a change not in the types of the races, (for each continent retains its characteristics,) but a remarkable dwindling in the size of species. In North America the Buffalo became the successor to the huge Mastodon, Elephant, and the Bootherium; the small Beaver to the great Castoroides; and the existing Carnivora are all comparatively small.

Parallel with this fact, we find that in South America, as Dr. Lund observes, where, in the last age before Man, there were the giant Megatherium and Glyptodon, and other related Edentates, there are now the small Sloths, Armadillos, and Ant-eaters.

So, also, on the Oriental continent, the gigantic Lion, Tiger, Hyena, and Elephant, and other monster quadrupeds, have now their very inferior representatives.

In New Holland, too, the land of Marsupials, there are Marsupials still, but of less magnitude.

2. This American continent has contributed to science a knowledge of some of the earliest traces of Reptiles,—the species of the Pennsylvania coal formation, described by Mr. King and Mr. Lea, and others from the Nova Scotia coal-fields, discovered by Messrs. Dawson and Lyell.

It has afforded the earliest traces of birds thus far deciphered in geological history,—the colossal and smaller waders, whose tracks cover the clayey layers and sandstone of the Jurassic rocks in the Connecticut valley. The earliest Cetacea yet known are from the American Cretaceous beds, as described by Dr. Leidy. And among the large Mammals which had possession of the renewed world after the Cretaceous life had been swept away, the largest, as far as has been ascertained, lived on this continent. The Palæotheria of the Paris Basin, described by Cuvier, were but half the size of the allied Titanotheria of Nebraska.

But here our boasting ceases, for, as Agassiz has shown, the present Fauna of America is more analogous to the later Tertiary of Europe than to the existing species of that continent.

In the Palæozoic Ages, to the close of the Coal Period, the American continent was as brilliant and perhaps as profuse in its life as any other part of the world. It was a period, indeed, when the globe was in an important sense a unit, not individualized in its climates or its distribution of life, and only partially in its seas. But from this time the contrast is most striking.

The whole number of known American species of animals of the Permian, Triassic, Jurassic, Cretaceous, and Tertiary Periods is about two thousand; while in Britain and Europe, a territory even smaller, there were over twenty thousand species. In the Permian we have *none*, while Europe has over two hundred species. In the Triassic, *none;* Europe, one thousand species. In the Jurassic, (the supposed Triassic here included) sixty; Europe, over four thousand. In the Cretaceous, three hundred and fifty to four hundred; Europe, five to six thousand. In the Tertiary, hardly fifteen hundred; Europe, about eight thousand.

America, since Palæozoic times, has therefore been eminent for the poverty of its Fauna.

Again: the Mammalian Age in America, although commencing with huge Pachyderms, shows little progress afterward. The larger quadrupeds continue to be mostly herbivorous, and the Carnivora, the higher group, are few and of comparatively small size. *The Herbivora are still the typical species.* While in Europe and Asia, at the same time,—that is, in the Post-tertiary,—the Carnivora are of great size and ferocity, far exceeding the largest of modern Lions and Tigers, and they exist in immense numbers. The single species of Lion described by Dr. Leidy, from a bone from near Natchez, hardly lessens the contrast.

South America, as has been remarked by Agassiz and others, sustains the inferior position of America. The huge Sloths, Megatheria, and other Edentates of the South, are even lower in grade than the ordinary Herbivora, and place that Southern continent at an inferior level in the scale. Although there were Carnivora, they were much smaller than the European. *The Edentates are its typical species.*

The supremacy of the great Oriental continent is, therefore, most signally apparent.

The contrast is still greater with Australia and New Zealand, whose past and present Fauna and Flora have been well said by Agassiz and Owen to represent the Jurassic Period,—the present era affording Trigonias, Terebratulæ, Cestraciont Fishes, and the Araucarian Coniferæ, all Jurassic types, besides Kangaroos and Moas. Among Mammals, as is well known, *the Marsupials*, the lowest of all in the class, *are its typical species.*

Ever since Palæozoic times, therefore, the Oriental Continent,—that is, Europe, Asia, and Africa combined,—has taken the lead in animal life. Through the Reptilian Age, Europe and Asia had species by thousands, while America was almost untenanted. In the later Mammalian Age, North America was yet in the shade, both in its Mammals and lower tribes; South America in still darker shadows; and Australia even deeper still. The earth's antipodes were like light and darkness in their zoölogical contrasts. And was there not in all this a prophetic indication, which had long been growing more and more distinct, that the Eastern Continent would be man's chosen birthplace? that the long series of living beings, which had been in slow progression through incalculable ages, would there at last attain its highest exaltation? that the stupendous system of nature would there be opened to its fullest expansion?

Another of our number has shown in eloquent language how the diversified features and productions of the Old World conspired to adapt it for the childhood and development of the race; and that, when beyond his pupilage, having accomplished his rescue from himself and the tyranny of forces around him, and broken the elements into his service, he needed to emerge from the trammels of the school-house in order to enjoy his fullest freedom of thought and action, and social union. Professor Guyot observes farther, that America, ever free, was the appointed land for this freedom and union,—of which its open plains, and oneness of structure, were a fit emblem; and that, although long without signs of progress or hope in its future, this land is to be the centre of hope and light to the world.

In view of all these arrangements, man may well feel exalted. He is the last of the grand series. At his approach, the fierce tribes of the earth drew back, and the race dwindled to one-fourth its bulk and ferocity,—the huge Mastodons, Lions, and Hyenas yielding place to other species, better fit to be his attendants, and more in harmony with the new creation. Partaking of the Divine image, all nature pays him tribute; the universe is his field of study; an eternity his future. Surely it is a high eminence on which he stands.

Yet he is only *one* of the series; one individuality in the vast system. How vain the philosophy which makes the creature the God of nature, or nature its own author! Infinitely beyond man, infinitely beyond all created things, is that Being with whom this system, and the combined systems of immensity, were as one purpose of His will.*

* This Address, exclusive of the notes, is cited from the Proceedings of the Amer. Assoc. IXth Meeting at Providence, R. I. It was delivered by the author on retiring from the duties of President.

Art. XXV.—*On the Plan of Development in the Geological History of North America*, with a map; by James D. Dana.

On other occasions, I have discussed at some length, the outline and surface features of the continents, the parallel courses of island groups, and the relations between the structure of the continental borders and the extent of the adjoining oceans; and I have endeavored in connection to elucidate the great principle of geological dynamics, which is at the basis of these characteristics of our globe.* I propose at this time to point out the relations between the operations of this principle or agency and the special geological history of the North American continent.

To render this application of the subject intelligible, it is necessary to review briefly the fundamental facts just alluded to. For this purpose, I would direct attention to a Mercator's Chart of the World, (see plate) on which the whole is open to examination—such a chart being a minature representation of the facts themselves, and the order observed among its parts, the syllables which spell out the principles.

In the first place, note the two great oceans, the Alantic and the Pacific—both widening south, and coalescing in a vast ring of ocean around the south pole, while narrowing north and uniting in a small arctic sea. The Indian Ocean is a third north and south ocean: but it reaches north only a little ways beyond the equator.

As the Atlantic is less than half the breadth of the Pacific, so the American continent is less than half the breadth of the great Orient, including Europe, Asia and Africa. It is seen also that while the North Atlantic treads off to the northeast, and the whole Atlantic is a zigzag channel with a main *northeast* course, the Pacific is a *northwest* channel, its longest diameter (represented by the line M M), being at right angles nearly with the trend of the Atlantic (N N). This longest diameter, moreover, corresponds with the general trend of the Pacific islands; for these islands have a nearly parallel course all through the ocean, the New Hebrides, Kingsmills, Samoan, Tahitian, Marquesas and Sandwich islands, lying in approximately parallel lines.†

* Am. Jour. Sci., [2], ii, 335, 352, iii, 94, 176, 381, iv, 88; Report, Geol. Expl. Exped., 756 pp. 4to., 1849, pp. 11, 414, 429; Proceedings Amer. Assoc. vol. ix, Providence Meeting, 1855, and page 305 of this volume.

† I may here add, what I have elsewhere explained at length, that the trends of the Pacific, while having a general correspondence of direction, pertain to two systems, one the Central Pacific, the other the Australasian. The Central Pacific begins in the Paumotu Archipelago, or rather still farther east, in Easter Island and Gomez; is thence continued on a west-northwest course, by the Society Islands, and the Hervey Islands more south; thence by the Samoan and Fakaafo groups; thence more northwesterly by the Vaitupu and Kingsmills, to the Radack and Ralick groups,

In the body of New Zealand, however, and some other parts, the transverse trend of Eastern America is represented.

Now what is the relation between the borders of the continents as to features and structure, and the extent of the oceans?

1. Look first to North America. Observe the general direction of the coast conforming to the prevalent trends of the globe, the northeast and northwest, and thus giving it its triangular form. See the low Appalachians facing the *small* Atlantic, the lofty Rocky Mountains, mostly a double line of heights, facing the *broad* Pacific, besides a second towering range, the Cascade and Sierra Nevada, nearer the sea. May we not say, *As the height of the Appalachians to the size of the Atlantic, so is the height or extent of the Rocky range to the size of the Pacific*?

In South America, there is the same relation—the low Brazilian mountains on the Atlantic side, the lofty Andes on the Pacific, and the latter exceeding the Rocky Mountains as much as the South Pacific exceeds the North Pacific; so that we may make another proportion, *As the height of the Rocky Mountains to the North Pacific, so is the height and boldness of the Andes to the South Pacific.*

In the Orient, the mountains towards the Atlantic, or those of Europe, are low and limited, compared with the long and lofty ranges of the Pacific side; and these last are inferior to the Himalayas, the sublimest heights of the world, which face the Indian ocean—a large and open ocean, while the Pacific towards Asia is much encumbered by islands.

In Africa, the loftiest and longest mountains are those of Abyssinia, on the east, facing the Indian Ocean, some of whose ridges are eleven to fourteen thousand feet in height, and one

which run nearly north-northwest; making thus a great sweeping curve, of several strands, over 6000 miles long. The Sandwich or Hawaian islands on the north side of the equator (2000 miles in whole length) is the opposite or northern side of the same system, slightly curving with the convexity to the north: while the Marquesas and the Fanning or Washington group lie along the axis of this great Central Pacific area. The other system is concentric around Australia, (New Holland). The line of new Hebrides, near northwest in course, is continued in the Salomon Islands, and New Ireland, becoming gradually east and west in the Admiralty Islands, north of New Guinea. The line of New Caledonia, another curving strand in the system, is continued in the Louisiade group and New Guinea, and becomes east and west in western New Guinea. The foot of the New Zealand boot, and the Coral Archipelago between New Caledonia and Australia accord with the system. The position of these lines concentric around Australia correspond with the idea that the position and extent of this continent, has had some influence in determining the directions.

These two systems, the Central Pacific and Australasian, though so distinct, are yet bound together in one. For while the great central range has its main course along the Kingsmills and Radack groups, it sends off at the Kingsmills, a western branch, the Carolines, which is actually parallel with the lines of the Australasian system.

The transverse trend of New Zealand, which is continued in the Friendly Islands north, is the correlate of the northwestern, the two having a mutual dependence, and together distinguishable in many groups of islands as well as in the features of the Continents.

peak near the equator is 20,000 feet. In Australia, the Australian Alps, as they are called, are on the east fronting the Pacific, here the wider of the bordering oceans.

Thus all over the world, the highest mountains stand fronting the largest and deepest oceans; and the "rule of three" statement of the fact scarcely conveys a wrong impression.

2. We observe further that the coasts are in general so turned as to face the widest range of ocean. The Appalachians with the neighboring coast do not face northeast towards the European continent, but southeast, towards the great opening of the Atlantic between America and Africa. So on the west side of North America the Pacific coast faces, not towards Asia, but southwest, where the broadest range of ocean is before it.

3. Consider now a little more closely the structure of these ocean borders. How is it as to the effects of heat or volcanic action?

In North America, on the side of the *small* ocean, the Atlantic, we find metamorphic rocks, some trap dykes, and a few tepid springs. On the side of the *great* ocean, the Pacific, all these phenomena occur, and besides, some of the grandest volcanoes of the globe, while basaltic floods have buried out of sight almost all other rocks over a considerable part of the country. Mount St. Helens, Mount Hood, Mount Shasta, and a dozen others, twelve to eighteen thousand feet high, make a majestic file of fire mountains not yet wholly extinct. May we not then say, *As the size of the Atlantic to the action of heat on the Atlantic border, so is the size of the Pacific to the action of heat on the Pacific border*?

In South America, there is a direct repetition of the same facts on a still grander scale: the Brazilian side, with metamorphic rocks and no volcanoes; the Pacific side, with volcanic heights of 20,000 feet and upward.

In the Orient, there are some small volcanic operations on the Atlantic side; but an unnumbered host down through Kamtschatka, Japan, and the islands south on the Pacific side.

In Africa, there are great volcanoes in the Red Sea and the lofty Abyssinian mountains, and only a few on the east, in the Gulf of Guinea, where, in fact, the continent opens on the Southern Ocean and not simply on the narrow Atlantic; the volcanoes are at the junction of the two lines, in or near the Bight of Biafra.

4. Again, these effects of heat are confined mostly to the region between the crest of the border mountains and the ocean, and are most intense towards the coast line. Thus the crystallization or metamorphism of Eastern North America, from Labrador to Georgia, is strongly marked towards the ocean, and diminishes going westward. So on the Pacific side: the great

volcanoes are not on the east or landward side of the crest, for there is not a volcano on that side, but on the seaward side, and not very far from the ocean. Thus we may almost say, *The nearer the water, the hotter the fire.*

5. Again, the mountains that make the borders, consist as is now well known since the surveys of the Professors Rogers, of rocks that have been pressed up out of place into a series of immense folds, like the folds we may make in paper by pressing laterally; only the rocky folds are many miles in range and of mountain height; and these folds or plications and displacements are most numerous towards the ocean, and are parallel nearly to the ocean. Hence again, *The nearer the water, the vaster the plications of the rocks.*

6. Over the interior of North America, there are not only no volcanoes, but there never have been any since the earlier Silurian, as shown by the absence of their remains among the strata; and this is so, notwithstanding the abundance of salt water over the regions in those ancient times. Over the interior of Asia there are no volcanoes, as is well known, except the three or four in the Thian-Chan Mountains. The great volcanic belt of the Orient stands out a short distance from the water-line of Asia, in the Japan range of islands, thus directly edging the oceanic basin; for the intervening region of shallow waters is properly a submerged part of the continent.

7. In contrast with this non-volcanic character of the interior of the continents, the islands of the oceans, it should be remembered, are all volcanic where not coral, and those of coral probably rest on a volcanic basis. Dhwalagiri, in the Himalayas, 28,000 feet high, is granitic; and surely we might have looked for some granitic peaks among the central islands of the oceans: but there are none.

At the same time, as others have remarked, the transverse seas which divide the Northern and Southern continents, the East Indies, the Mediteranean and West Indies, are characterized by volcanoes.

If then, the typical form of a continent is a trough or basin, the oceanic borders being raised into mountains; if these borders are so turned as to face the widest range of ocean; if the height of these border mountains and the extent of igneous action along them is directly proportioned to the size of the oceans,—the Pacific, accordingly, being girt with great volcanoes and lofty mountains, while the narrow Atlantic is bounded by smaller heights and but few volcanoes; if, moreover, volcanoes characterize the islands of mid-ocean and not the interior of the continents: What is the legitimate inference?

Most plainly, that the extent and positions of the oceanic depressions have some way determined, in a great degree, the fea-

tures of the land; that the same cause which originated the one, impressed peculiarities on the other; that the two had a parallel history through past time—the oceanic depressions tending downward, the continents upward; in other words, that they have both been in progress with mutual reaction from the beginning of the earth's refrigeration. The continents have always been the more elevated land of the crust, and the oceanic basins always basins, or the more depressed land.

We thence learn that the profounder features of the earth were marked out in the earliest beginnings of geological history, and that the whole subsequent progress has been a working on this basis. Other and more direct evidence of this fact I alluded to in my address before this Association last year—evidence derived from the extent and nature of the Potsdam sandstone, the earliest of the Silurian strata, showing that this primal rock was laid down over a large part of North America by a sea which just bathed its surface—thus proving that the continent was already made, and indicating in part its water level.

The relation between the extent of the oceans and the border features of the continents, which has been pointed out, is not simply a relation of fact, but of effect and dynamics, pointing to a unity of cause. The one cause is assuredly not in the waters of the oceans, for these are inert: they cannot bake rocks, light up volcanoes, fold the heavy strata, and make mountains. The cause is no paroxysmal force, exhausted in a temporary freak of nature. It is some profound, systematic, untiring force, which in its slow movement, has counted centuries as if seconds. The Appalachian range is one mark of its power; but not the result of a fitful heave: on the contrary, a work of time, and time so long, that the resisting strata could bend in many plications without being reduced to chaos; so long, that New England and regions south, which entered the period of catastrophe as a territory of sedimentary beds, came forth at last a region of granite, gneiss and crystalline schists. Most of the mountains of the globe, for the reasons stated, we must regard as other effects of this fundamental cause; and it is therefore no matter of surprise that they should have in general a common system of structure.

A unity of cause there must be for the great phenomena of geology. Such is nature in all her departments. Details are the means by which we penetrate to the deep-seated cause; and when that cause is once reached and fully apprehended, the details have new interest from the harmonious relations thus developed,—as the leaves and twigs of a tree derive their grandeur and the most of their beauty from the rising trunk and spreading branches to which they are subordinate, and with which they are in perfect harmony.

What then is the principle of development through which these grand results in the earth's structure and features have been

brought about? We detect a plan of progress in the developing germ; we trace out the spot which is first defined, and thence follow the evolution in different lines to the completed result: may we similarly search out the philosophy of the earth's progress?

The organizing agencies in the sphere are—

1. Chemical combination and crystallization.

2. Heat, in vaporization, fusion, and expansion, with the correlate force of contraction which has been in increasing action from the time the globe began to be a cooling globe.

3. The external physical agencies, preëminently water and the atmosphere, chiseling and moulding the surface.

4. The superadded agency of life.

Of these causes, the first is the molecular power by which the material of the crust has been prepared. The third and fourth have only worked over the exposed surface. But the second, while molecular in origin, is mechanical in action, and in the way of contraction, especially, it has engaged the universal sphere, causing a shrinkage of its vast sides, a heaving and sinking in world-wide movements. Its action therefore, has been coextensive with the earth's surface throughout the earth's history. If a power at all, it has been a dominant power in the great changes, and in connection with the profound structure of the crust received through consolidation, it has wrought out the earth's lineaments, varying them with her years from the first featureless sphere to the bold expressiveness and wrinkles of age. This is the cause that most concerns us at this time.

There must be system in the intimate structure of the crust. For if it was once fluid, and is now one or two scores of miles thick, all this thickness beyond that of the first film has been produced through gradual, exceedingly gradual and prolonged cooling, adding, by downward increase, to the solid surface arch: and if ice over a pond when thickening in this same way by additions downward to the surface film takes a crystalline texture perpendicular to this film, as has been proved, we may safely infer that the crystallization of the earth's crust as it slowly thickened would have taken a regular structure, and the more surely since we know that the mineral feldspar, which gives a cleavage structure to granite, is the prevailing mineral in all igneous rocks. Thus we approach some explanation of the prevalence of two great systems of trends in the features of the globe. But this subject we pass by, to the one which more immediately concerns us—the surface features of the continents.

The contraction to which I have alluded, going on after a crust was formed over the earth, would necessarily fracture, displace, or wrinkle the crust, as the same cause, contraction, wrinkles a drying apple. The large rind is more than sufficient for the contracted sphere; and the drawing downward of some parts

must cause the bulging of others. If any large areas of the crust were sinking more than the rest, this very subsidence would necessarily push up the borders of these areas into angular elevations or folds; and it follows necessarily,—the larger these areas the higher the border elevations.

These are the simple principles. The oceanic basins are these areas of greatest subsidence; and hence would necessarily flow the law, already established as a matter of fact—the larger the ocean, the higher the mountains on its borders, the deeper the fractures and displacements there, and the vaster the outflow of internal heat and lavas. The size, therefore, of the oceans, that is, their extent and depth, is relatively a measure of the force exerted on their sides.

The wrinkles or elevations on the globe seem large when man measures them by comparison with his own stature. But a section of the land, true to nature, corrects this misapprehension. In a section of the North American continent, drawn to a scale twelve feet long, one-ninth of an inch will stand for an altitude of 10,000 feet; one-sixteenth of an inch for the White Mountains, and about three-tenths for the Himalayas.

After this review of principles, let us now turn our attention to North America and seek out its plan of development.

I. The triangular form of the continent has been noted and its simple ocean boundary: and it should be observed that the continent is set quite to the west of South America, so as to possess this simplicity of boundary and therefore of moulding forces in its highest perfection.* The small Atlantic on one side, and the great Pacific on the other, indicate approximately the relative amounts of force from the two directions, the southeast and southwest, during the progressive ages of the history;—that to the eastward the power was comparatively moderate, gently folding up the Appalachians, and to the westward it was strong and mighty, even to the raising of the Rocky range and opening the great volcanoes of Oregon. We thus learn, with a degree of precision not to have been anticipated, the direction and efficiency of the great organizing forces.

Glance now at American geological history from this point of view, and consider where was the first germinant spot of the growing continent, and what was thence onward the course of development under the influence of this agency.

The earliest spot or primal area will be that of the Azoic rocks, the first in the geological series. Such an area (see Chart, A A A) extends from Northern New York and Canada, north-west to the Arctic Ocean, lying between the line of small lakes (Slave, Winnipeg, &c.) and Hudson Bay. East and west, it dips under

* The contrast with Europe in this respect is striking, and accounts, as I have said, (Address, &c., p. 311,) for the greater simplicity of North American Geology.

Silurian strata (S S;) but it is itself free from superincumbent beds, and therefore, even in the Silurian age, it must have been above the ocean. And ever since, although subject, like the rest of the world, to great oscillations, it has apparently held its place with wonderful stability, for it is now, as probably then, not far above the ocean's level.

This area is central to the continent; and, what is of prominent interest, it lies parallel to the Rocky Mountains and the Pacific border, thus proving that the greater force came from that direction in Azoic times, as well as when the Rocky Mountains were raised. Thus this first land, the germ or nucleus of the future continent, bears in itself evidence with respect to the direction and strength of the forces at work. The force coming from the Atlantic direction has left comparatively small traces of its action at that time. Yet it has made its mark in the Azoic stretching through Canada to Labrador, in the dip and strike of the New York Azoic rocks, in the direction of the channel of the St. Lawrence and the northwest coast of Lake Superior, and probably also in the triangular form of Hudson's Bay. Against this primal area, as a stand-point, the uplifting agency operated, acting from the two directions, the Atlantic and the Pacific; and the evolution of the continent took place through the consequent vibrations of the crust, and the additions to this area thereby resulting; the ocean in the meantime pursuing its appointed functions in the plan of development, by wearing exposed rocks and strewing the shores and submerged surface with sand, gravel or clay, or else growing shells, corals and crinoids, and thus storing up the material of strata and burying the life of successive epochs.

These long secular vibrations, movements by the age rather than day, dipping the surface and raising it again in many and varying successions, were absolutely essential to the progress. Had the continent been stable, there could have been no history, no recorded events of changing life and alternating deposits: all would have been only a blank past. These forces, therefore, working mainly from the southeast and southwest, were actually organizing forces, essential to the completion of the continent,—to the production of its alternations of limestones, shales, sandstones and conglomerates, and its sweeping catastrophes burying the old preparatory for higher forms of life:—the continent in the course of these movements, being at one time, it may be, just beneath the ocean's surface, and having beds of sand and gravel accumulating under the action of the waves; then in somewhat deeper and clearer waters, with limestones forming from coral or crinoidal plantations or the growth of shells; then, perhaps, rising from the waves, bringing death upon its sea tribes in one universal desolation; then, sinking slowly in the waters

again, and varying in its accumulations from sandstones to shales, pebble beds or limestones, with the depth and the currents; and then again above the tides, although destruction to all the life of the ocean was in the movement; and, perchance, lying in the open air for an era, to receive the mists and rains and sunshine, and become luxuriant through new creations with broader prairies than now cover the West. Alternations like these were again and again repeated, as geology has shown.

Through these means, the continent, which was begun at the far North, a region then tropical but afterwards to become inhospitable, gradually expanded southward, area after area as time moved on being added to the dry land.

First, as the facts show, the Silurian deposits of Canada and the North, adjoining the Azoic, were left above the sea, for these rocks there are not overlaid by later beds; and, therefore, were not the sea-bottom of later seas. Next, the adjacent Devonian were added to the main land as far south as Southern New York and around by the west; for, as the New York geologists have shown, the carboniferous beds which come next do not reach into that State. By the time of the Jurassic period, the continent had expanded much farther to the southward, for the carboniferous rocks over the land were out of water, their beds having already been folded up and elevated in the Appalachians. The red sandstone of the Connecticut Valley and of the Atlantic States from New York to Alabama leave little doubt as to the water line of that era. In the Cretaceous period the continent had farther expanded along the Atlantic; but in the Mississippi Valley the Mexican Gulf still extended north even to the head waters of the Missouri. Next, as the Tertiary opened, the continent had yet more widely enlarged its bounds, south and southeast; and if the waters of the Mexican Gulf for a while claimed a place over some part of the Nebraska plains, as late observations suggest, by the close of the period the continent in this direction had nearly reached its full maturity. These steps of progress are indelibly marked in the position, and obvious seacoast, off-shore or estuary origin of the Jurassic, Cretaceous and Tertiary beds of the country.

Passing towards the Pacific, we find evidence in the carboniferous limestone that the Rocky Mountains were mostly under shallow water as the Carboniferous age opened, the mountains themselves unborn. Later in the Cretaceous and Tertiary periods, as the rocks towards the coast testify, the continent had extended far to the southwest, and was nearly complete in that direction, as well as to the south and southeast.

Thus the enlargement went on to the southward, each period making some addition to the main land, as each year gives a layer of wood to the tree. Not that this addition was free from

oscillations, causing submergences, for these continued long to occur; but the gain, on the whole, was a gain—a progress; and the moving ages made the accession a sure and permanent gain as the continent became more stable.

II. But in the statement that the growth of the continent was to the south, southeast, and southwest, we assert only the most general truth respecting it. The continent has its special features as much as any being of organic growth, and the elimination of these features is to be traced to the same system of forces. The Appalachian range on the east, the Rocky Mountains and the subordinate chains on the west, the lower lands and lakes of the interior, all in systematic relation, are the more marked of these features; and the vast river systems, with the broad alluvial flats and terraced plains, the wide spread drift, the denuded heights and channeled slopes and lowlands, are subordinate peculiarities of the face of the continent.

The Appalachian range of heights, as I explained a year since, was commenced in the Silurian age, and even earlier long before a trace of the mountains had appeared.* The force from the southeast, in the dawn of the Palæozoic era, had made the Appalachian region generally shallower than the Mississippi valley beyond. The vast sandstone and shale deposits of the region bear marks in many parts of sea-shore action, while the limestones which were forming cotemporaneously farther west, indicate clearer and somewhat deeper seas; and the patch of Azoic in northern New York, lying at the northern extremity of part of the range, points to an anterior stage in the same course of history; so that, in early time, long before there were mountains, the future of the continent, its low centre and high borders, was foreshadowed. We can hardly doubt that the region of the Rocky Mountains was in the same condition, in the main, with that of the Appalachians. Moreover, these borders, or at least the eastern, for ages anterior to the making of the mountains, were subject to vastly greater oscillations than the interior; for the Silurian and Devonian sandstones that occur along from New York to Alabama are of great thickness, being five times as thick as the limestones and associated deposits of the same age to the west. A limestone bed, moreover, is of itself evidence of comparatively little oscillation of level during its progress.

We hence learn that in the evolution of the continental germ, after the appearance of the Azoic nucleus, there were two prominent lines of development; one along the Appalachian region, the other along the Rocky Mountain region—one, therefore, parallel with either ocean. Landward, beyond each of these developing areas, there was a great trough or channel of deeper ocean waters, separating either from the Azoic area.

* Address &c.—See this volume, page 319.

The Azoic, as has been indicated, has something of a V shape, (or ∨), with Hudson Bay between its arms. This succeeding step of progress is the partial development of a larger V outside of and parallel to the Azoic nucleus. The channels alluded to lie between the two V's. The bar of the outer V on the left is of great breadth and made up of several broad parallel bands or ranges of elevations; that on the right is quite narrow comparatively, yet also etched in several parallel lines.

The Mexican Gulf is all that remains of the larger of these channels. Its waters once stretched to the Arctic Sea, and were in early time but the deeper part of the continental ocean. Later, as the ages moved on, there was land to the north, and a line of freshwater lakes along its former course; and the Gulf reached no higher than the headwaters of the Missouri. Later still, and its limits became more contracted, till now the full-grown continent has but her foot in the salt water.

The Gulf of St. Lawrence marks the outlet of the other channel, and the River St. Lawrence its course. The great lakes, as well as the smaller lakes north, lie near the limits of the Azoic nucleus within these ancient troughs or depressions; and the largest lake, Lake Superior, is at the junction of the two lines.

Such was the law of growth. The molecular forces *beneath* the continent, from the progressive cooling there going on, were not idle, and must have modified the results. But the main action causing the lifting and sinking of the crust and the final gain to the land, proceeded from the directions of the oceans. The inequality in the forces from the two directions, as well as in the form and depth of each oceanic or subsiding area whence the forces mainly came, would necessarily have produced many irregularities in the results, as I have remarked in another place,* and will not now dwell upon.

The Pacific region has always been true to its own grandeur. The force from that direction not only made the Rocky Mountains to rise and a file of lofty volcanoes to light up its waters, (while the most the gentler Atlantic could accomplish was a bending up of the strata into Appalachians, and a baking of some of the beds,) but it also added tenfold the most dry land to the continent; and even after the tertiary rocks were deposited, it elevated the continental border at least two or three thousand feet—ten times beyond what happened on the Atlantic side.†

* Amer. Jour. Sci. [2], vol. iii.

† Whatever doubts may exist as to the cause, there can be none as to the actuality of the force on the two sides, the Atlantic and the Pacific. The elevation of the mountains on each border is proof beyond question; and their relative extent and height is evidence indubitable as to the relative amounts of force exerted. The parallel *folds* on the Atlantic side show that there it *was actually lateral* force from the southeast; and the several parallel ranges on the Pacific side, parallel to the

But look further, and consider that the great lines of elevation on the Pacific side are parallel nearly to the islands of the ocean; that these islands are like a long train stretching off from Asia to the east-southeast; that New Hebrides, New Caledonia in the southwest, with the foot of the New Zealand boot and northwestern Australia, conform to the general parallelism; and it will then be comprehended that we have been considering not simply a continental system of progress, but one involving the whole globe. It appears also from the history of the coral islands of the Pacific, that while the Tertiary and Post-tertiary elevations were going forward on the Pacific border of North America, a slow and gradual subsidence was in progress over a parallel region across the middle of the ocean. The axis line of the Pacific is not only the main trend of its lands, but is also nearly the course of the great subsidence which is indicated by the history of the coral islands.*

III. I have said that these two systems of forces—the southeast and southwest—continued to act through the Tertiary period, working out the continent, and bringing it nearly to its adult extent. At the meeting of this Association at Providence I pointed out the fact that at the close of the Tertiary there was a change in the movement; that during the following period, the Post-tertiary, there were high-latitude oscillations; and I endeavored to show, that there was first an elevation of the continent over the north for the first or glacial epoch; then a subsidence (as shown by the seashore deposits on Lake Champlain, and the highest terrace of the lakes and rivers) during a second or Laurentian epoch; and finally, an elevation to its present height, for the third or Terrace epoch. Whether the elevation for the Drift epoch be admitted or not, all agree that the oscillation attending it was a northern phenomenon. These several changes thus affected mainly the latitudes north of the middle of the temperate zone, or were but slightly felt to the south of this. It is a remarkable fact that the coasts of the Arctic regions, which have now been rather widely explored, have not presented any Jurassic, Cretaceous or Tertiary deposits, and there is, therefore, no evidence of their

ocean, are proofs of similar lateral action there, but from the southwest. Then the dominance of these two trends in the uplifts over the whole continent in its oldest and newest regions and rocks, are like the warp and woof of a fabric, determined by the organizing forces themselves of the structure.

* Amer. Jour. Sci. vol. xlv, (1843) 131, and [2], iii, 396, (1847).

One consequence of these facts and principles may be here alluded to.—If the position of the Atlantic and Pacific has determined the main directions of the organizing forces through all time, and if, owing to the direction, as the facts show, elevations having the *same* strike or trend have been formed in successive geological ages, it is evident that the elevation theory of mountains, sustained by Elie de Beaumont, must be received with much hesitation. One dial-plate for the world, such as he has deduced mainly from European geology, is a splendid hypothesis; but it may not mark time for America or the other continents.

having been in those eras under water. Such beds may hereafter be detected; but the great fact will still remain, that they are there of limited extent, if not wholly absent. As far as known, there is no Tertiary on the coasts north of Cape Cod. All development or growth there seems to have ceased, or nearly so, with the Palæozoic era or the close of the Carboniferous age. But there are Post-tertiary deposits in the Arctic regions in many places, situated hundreds of feet above the sea, containing shells of existing Arctic species. This alone, independent of other evidence, would prove a change in the conditions of geological progress after the Tertiary period. The necessary inference is, then, that as long as the southwest and southeast forces were in active play, and the extremities of the continent were thereby in process of growth, there was little change going on in the far north. But when the continent was nearly finished, its extremities grown, and the stability consequent upon adult age acquired, then, through a series of oscillations, a course of development was carried on in the more northern regions, giving a final completion to the continent—an action, which, as I have elsewhere explained, involved the higher latitudes about the whole sphere, north and south of the equator.*

We shall understand more definitely the relations of the later to the older oscillations, if we consider that all were due to one grand cause, influencing the whole extent of the continent even to the Arctic ocean; that the force from the north, the southeast, and the southwest, according to the principle explained, was proportioned approximately to the sizes of the oceans, the Arctic, the Atlantic and the Pacific; that the greater forces from the southeast and southwest acted against that from the north, and through their superior strength or the concurrent greater flexibility of the crust, kept up those vibrations in the progress of which the border mountains were made; but at last, the southeast and southwest action almost ceasing through the stiffening and uplifting of the crust, then the northern force, having a stable fulcrum, made itself felt in the long and slow oscillations of the Post-tertiary. Under this mode of view it will be seen that all was part of one system of development.

If we rightly apprehend the results of the Post-tertiary period, we shall perceive that there was vast importance in these finishing operations over the sphere:—that during its progressing centuries, the great phenomena of the drift took place, covering hills and plains with earth; that the valleys for our rivers were then either made or vastly enlarged; that immense alluvial plains were spread out in terraces over the interior and in flats along the shores; that thus a large part of the brighter fea-

* Address, etc., this volume, p. 327.

tures of the globe were educed. The mountains of the earth at last stood at their full altitude, having gained some thousands of feet since the Tertiary; and rivers, true offspring of the mountains, taking their size from the size of the mountain ranges, were sent on renovating missions over the breadth of the continents. Indeed, the upper terraces of the rivers show that during the Post-tertiary, these interior waters had an extent and power vastly beyond what the streams now exhibit;—an extent which is yet unexplained, unless attributable, as I have suggested, to the declining snows of a glacier epoch. In their strength, they deeply channeled the hills, and wrought out much of the existing sublimity of mountain architecture. There was the elimination of beauty and of immediate utility in every stroke of those later waters, in striking contrast with the earlier operations of rock-making and mountain-lifting; for those very conditions, those special surface details, were developed, that were most essential to the pastoral and agricultural pursuits with which man was to commence his own development, while that grandeur was impressed on the earth that should tend to raise his soul above its surface.

This transfer of the process of development from the extremities to the more northern regions, thence evolving these new and more refined qualities of inorganic nature and humanizing the earth, has a parallel in organic growth; for the extremities are finished and adult size attained before the head and inner being are fully perfected. The analogy is fanciful; yet it is too obvious a parallelism to be left unsaid on that account.*

* I have alluded on a former page to an analogy between the progress of the earth and that of a germ. In this, there is nothing fanciful; for there is a general law, as is now known, at the basis of all development, which is strikingly exhibited even in the earth's physical progress. The law, as it has been recognized, is simply this :—Unity evolving multiplicity of parts through successive individualizations proceeding from the more fundamental onward.

The earth in igneous fusion, had no more distinction of parts than a germ. Afterwards, the continents, while still beneath the waters, began to take shape. Then, as the seas deepened, the first dry land appeared, low, barren, and lifeless. Under slow intestine movements and the concurrent action of the enveloping waters, the dry land expanded, strata formed, and as these processes went on, mountains by degrees rose, each in its appointed place. Finally in the last stage of the development, the Alps and Pyrenees and other heights received their majestic dimensions and the continents were finished out to their very borders.

Again, as to the history of fresh waters.—The first waters were all salt, and the oceans one, the waters sweeping around the sphere in an almost unbroken tide. Fresh waters left their mark only in a rain-drop impression. Then the rising lands commenced to mark out the great seas, and the incipient continents were at times spread with fresh-water marshes into which rills were flowing from the slopes around. As the mountains enlarged, the rills changed to rivers, till at last the rivers also were of majestic extent, and the continents were throughout active with the busy streams, at work channeling mountains, spreading out plains, opening lines of communication, and distributing good every where.

Again, the first climates were all tropical. But when mountains and streams were attaining their growth, a diversity of climate, (essential to the full strength of

Thus, then, the continent was completed. Contraction was the power, under Divine direction, which led to the oscillations of the crust, the varied successions in the strata, and the exuviations of the earth's life, era after era. Acting from the Atlantic and Pacific directions, it caused the southern prolongation of the growing land from the icy North to the tropics, while it raised mountains on the borders, and helped to spread the interior with plains, varied slopes, and lakes. And, finally, through its action over the north, the surface received its last touches, fitting it for a new age—the Age of Mind.

ART. XXVI.—*Re-determination of the Atomic Weight of Lithium*; by J. W. MALLET, Ph.D.; Professor of Chemistry, Univ. of Alabama.

LITHIUM is one of the elements whose atomic weight has been several times made the subject of investigation by different chemists, and yet on examining the results of their labors we find that but one or two experiments free from serious objection are recorded, from which the received equivalent number of the metal has been calculated; and even in these experiments the method pursued has not, I believe, been such as to ensure the closest approximation to the truth. Yet the formulæ of the salts of lithia, and of minerals containing this alkali, would be seriously affected by any considerable error as regards the equivalent number assumed, since this is one of the very lowest to be found in the whole list of elements—the lowest among the metals, with the single exception of glucinum. The fact that Lithium does possess so small an atomic weight—a fact which is said to have led to the discovery of the metal by Arfwedson—is in itself very remarkable when we remember the much higher numbers by which the other alkaline metals, potassium and sodium, are represented; and it gives additional interest to accurate experiments made for the purpose of fixing the number with precision.

The following historical notice of what has been already done in this direction I have taken from a valuable little work by

the latter,) was gradually evolved, until winter had settled about the poles as well as the earth's loftier summits, leaving only a limited zone,—and that with many variations,—to perpetual summer.

The organic history of the earth, from its primal simplicity to the final diversity, is well known to exemplify in many ways the same great principle.

Thus the Earth's features and functions were successively individualized:—first, the more fundamental qualities being evolved, and finally those myriad details in which its special characteristics, its magnificent perfection, and its great purpose of existence and fitness for duty, largely consist.

A. C. Oudemans, Jr., published at Leyden in 1853,* which reviews the determination of the equivalents of twenty-two of the elements, chiefly those of the alkaline and earthy metals. The original memoirs I have for the most part been unable to consult; but the work of M. Oudemans supplies all necessary details of the experiments, and contains also judicious critical remarks upon the trustworthiness of the results.

In 1817 Arfwedson† discovered lithium, and in the course of his examination of the new element he obtained the following results from which to calculate its atomic weight.

(1.) 5·732 grm. of LiO,SO_3, prepared by dissolving carbonate of lithia in sulphuric acid, gave 11·454 grm. of BaO,SO_3.

(2.) ·597 grm. of LiO,SO_3 appeared to consist of ·406 grm. of SO_3 and ·191 grm. of LiO.

(3.) 4·204 grm. of chlorid of lithium gave 13·224 grm. of chorid of silver.

Soon after, Vauquelin‡ analyzed anhydrous sulphate of lithia, and found ·430 grm. of LiO,SO_3 to yield ·875 grm. of BaO,SO_3.

C. G. Gmelin§ found a little later that ·481 grm. of LiO,SO_3, precipitated by acetate of baryta, gave ·953 grm. of BaO,SO_3; and that the acetate of lithia produced in this experiment left on ignition ·316 grm. of carbonate.

Stromeyer‖ also analyzed sulphate of lithia, and stated its composition as

Lithia, - - - -	30·819
Sulphuric acid, - - -	69·181
	100·

In 1828 Kralovanszky¶ published some experiments on the equivalent of lithium, in which experiments, as in those of preceding chemists, the precipitation of a solution of sulphate of lithia by acetate of baryta was the method employed. In one analysis 2· grm. of neutral, strongly ignited LiO,SO_3, gave 3·985 grm. of BaO,SO_3; and a second analysis yielded a result from which a slightly higher atomic weight was deducible.

Hermann** was the next chemist who occupied himself with the equivalent of Lithium. He prepared carbonate of lithia by precipitating a strong solution of chlorid of lithium with carbonate of ammonia or of soda, washing and igniting the precipitate. A weighed quantity of this carbonate was then brought

* Historisch-Kritisch Overzigt van de bepaling der Æquivalent-gewigten van twee en twintig metalen door A. C. Oudemans, Jr.—Leiden 1853.

† Afh. i Kemi, Fysik och Mineralogie, vi. Schweig. Journ. xxii, 93–100. Ann. de Chim. et de Phys. [2], x, 82. Pogg. Ann. viii, 189.

‡ Ann. de Chim. et de Phys. [2], vii, 287. § Gilbert's Ann. lix, 238.

‖ Stromeyer, Untersuchungen i. 435. Schweig. Journ. xxxiii. 373.

¶ Schweig. Jour. liv, 234. Berz. Jahresb. ix. 93.

** Pogg. Ann. xv, 480. Berz. Jahresb. x. 96.

in contact with muriatic acid in a gas cylinder filled with mercury, and the carbonic acid evolved was measured. It was found in one experiment =60·98, and in another =61·00 per cent of the carbonate of lithia. Hermann also dissolved this carbonate in sulphuric acid, evaporated to crystallization, and dried the crystals of sulphate of lithia over a spirit-lamp. 100 parts of the dry salt gave an amount of sulphate of baryta corresponding to 74 parts of sulphuric acid.

In 1831 Berzelius* repeated the experiments of Hermann, and with the following results. 4·4545 grm. of fused carbonate of lithia dissolved in sulphuric acid gave 6·653 grm. of sulphate of lithia; and 1·874 grm. of this anhydrous sulphate gave 3·9985 grm. of sulphate of baryta.

In 1839 Hagen† reëxamined with accuracy some of the minerals containing lithia, and discovered that this alkali occurred in them, not pure, as it had been previously supposed, but accompanied by soda; and as in the preparation of lithia salts for analysis most of the earlier chemists had taken no steps for the separation of the soda, it became obvious that most of the determinations which had been made of the equivalent of lithium were necessarily quite erroneous; and that the results of Berzelius and Hermann alone deserved any confidence, the salts analyzed by them having been prepared from precipitated carbonate of lithia.‡

Hagen himself found that 1·002 grm. of pure sulphate of lithia in crystals left on being strongly heated ·852 grm. of the anhydrous sulphate, and being redissolved and precipitated with a salt of baryta gave 1·8195 grm. of sulphate of baryta.

The above are the results of the experiments which have been made up to the present time. I have not given along with each the equivalent number deduced by the analyst himself, but have preferred to make the calculation in each case, using the most recently determined equivalents for the other substances involved in the several processes,§ and I here present the results in tabular form—

* Pogg. Ann. xvii, 379. Berz. Jahresb. x, 96.

† Pogg. Ann. xlviii. 361.

‡ It is true that Arfwedson prepared his sulphate of lithia by dissolving the carbonate in sulphuric acid; but this carbonate seems to have been obtained by precipitating the sulphate of lithia (containing soda) with acetate of baryta, filtering, evaporating the filtrate, and igniting—a process which of course would not remove the soda.

§ The equivalents used are—

Oxygen,	100·	
Chlorine,	443·28	(Marignac).
Sulphur,	200·	
Carbon,	75·	
Silver,	1349·66	(Marignac).
Barium,	857·32	(Marignac).

Authority.	Salt analyzed.	At. Weight of Li.
Arfwedson 1st experiment,	Sulphate.	129·30
" 2nd "	"	135·22
" 3rd "	Chlorid.	126·71
Vauquelin,	Sulphate.	116·17
Gmelin 1st "	"	135·54
" 2nd "	Sulphate conv. into Carbonate.	108·22
Stromeyer,	Sulphate.	122·74
Kralovanszky,	"	131·40
Hermann 1st "	Carbonate.	75·97
2nd "	Sulphate.	75·82
3rd "	"	75·67
Berzelius 1st "	Carbonate conv. into Sulphate.	80·89
" 2nd "	Sulphate.	83·01
Hagen,	"	82·41

Of these sufficiently discrepant numbers, those of Arfwedson, Vauquelin, Gmelin, Stromeyer, and Kralovanszky are at once to be rejected, for the reason already mentioned, that the substance analyzed by each of these chemists was not in reality a pure salt of lithia, but a mixture of salts of lithia and soda. The determination by Hermann of the amount of carbonic acid in the carbonate was not conducted in a manner likely to yield the most accurate results, and probably the same objection may be made against Berzelius's first experiment, which was made with the same salt.

We find then but three numbers apparently deserving of much confidence, namely those deduced from the analysis of anhydrous sulphate of lithia by Hermann, Berzelius, and Hagen—one experiment by each of these chemists. Hermann's result differs very considerably from the other two, and, as is observed by M. Oudemans, should have less importance attached to it, since the original weighings are not recorded, but merely the per-centage of sulphuric acid deduced therefrom by the analyst. Berzelius's result has been generally taken of late years as the true one, and with it that of Hagen agrees pretty well.

We have thus the atomic weight of Lithium as the result of but two experiments, agreeing, it is true, fairly with each other, but both made by the same process—the precipitation of sulphate of lithia by a salt of baryta, washing, igniting, and weighing the BaO,SO_3 produced. And as it is well known that sulphate of baryta is washed with extreme difficulty, an excess of the barytic salt used for precipitation obstinately adhering to the precipitate even after a very large quantity of hot water has been filtered through it—this fact rendering the exact determination of the sulphuric acid difficult; and as the quantity of sulphate of lithia submitted to analysis in each of these experiments was but small, and therefore the effect of any trifling error in the estimation of the sulphuric acid would be more seriously felt—it seemed that the equivalent of the metal might be redetermined

with advantage, using a larger amount of a carefully prepared salt, better adapted to the purpose than the sulphate, and requiring the process of analysis to be varied. The salt chosen was the chlorid of lithium, and I shall describe first the mode of its preparation, and then the experiments which have been made upon its composition.

Crystallized spodumene from the granite of Goshen (Mass.), where the mineral occurs with blue tourmaline, beryl, and rose mica, was finely pulverized, and 1 part mixed with 3 or 4 of unslaked lime and about three-fourths of sal-ammoniac. The mixture was heated in large crucibles to the highest temperature of a good wind-furnace. This is the process proposed by Prof. J. L. Smith* for the analysis of silicates, except that he uses carbonate of lime instead of the caustic earth. The nearly fused mass was pulverized, mixed with water, and treated with sulphuric acid in excess. The solution was filtered off from the sulphate of lime and other insoluble matter, and the latter washed with plenty of water upon a cloth filter. The still milky liquid was boiled down to a moderate bulk, and precipitated with chlorid of barium; the sulphate of baryta thrown down was washed by decantation, and the solution was filtered through paper. The filtrate was now a solution of chlorid of lithium, free from sulphuric acid, but containing the chlorids of several other metals in admixture. It was carefully evaporated to dryness to get rid of any silicic acid, re-dissolved, precipitated with ammonia, sulphuret of ammonium, and carbonate of ammonia, filtered, evaporated to dryness, and the residue heated until all ammoniacal salts were expelled. The residue was then re-dissolved, the solution boiled with a little pure milk of lime, and filtered from magnesia. The lime in the filtrate was removed by oxalate of ammonia, and the solution was evaporated to dryness, and heated to expel salts of ammonia. The residue, now containing only the alkaline chlorids, was moistened with a little water and again dried at a gentle heat, not over 100° C. The dry mass was introduced into a glass-stoppered bottle, and a mixture of equal volumes of ether and absolute alcohol was poured upon it—solution of the chlorid of lithium being aided by shaking the bottle from time to time. After a few hours the clear liquid was decanted, and the alcohol and ether were distilled off. The dry residue left by the distillation of this first alcoholic solution was again treated with ether and alcohol, the liquid again decanted and distilled, and finally the same process of purification was repeated a third time, nothing being now left undissolved by the ether-alcohol. The pure chlorid of lithium

* Amer. Jour. of Science, [2], xv, 234; xvi, 53.

was fused in a covered platinum crucible, poured out upon a sheet of platinum, and the fused mass broken up while warm, and quickly enclosed in a bottle with a well ground stopper.

This anhydrous chlorid of lithium was beautifully clear and colorless, and a portion of it taken for careful qualitative examination appeared to be perfectly pure—it was at least completely free from any traces of the earths or heavy metallic oxyds, and might be fairly supposed to have been also freed from all chlorid of sodium or potassium by the repeated treatment with ether and absolute alcohol.

On fusion in an uncovered vessel for some time the salt loses a little chlorine, and takes up oxygen, so that when redissolved in water it reacts alkaline to test-paper; but it was found that this change could be completely avoided by mixing a little pure sal-ammoniac with the chlorid of lithium before evaporation to dryness, and fusing the dry mass in a covered crucible. The heat applied must not be too great until the sal-ammoniac has been driven off,—as in a first experiment, in which the quantity of NH_4Cl was considerable and the heat rapidly applied, the greater part of the chlorid of lithium was volatilized and lost, although the platinum crucible was covered and was not raised to more than a low red heat.

Having got then pure fused chlorid of lithium, it remained to determine its composition or the per-centage of chlorine which it contains. The salt is a deliquescent one, and it seemed doubtful at first whether the absorption of moisture could be prevented during weighing, but it was found that in a platinum crucible provided with a tightly fitted cover, the portion taken for analysis, consisting of but three or four fragments of the fused cake, could be weighed with ease and certainty; the weight remaining constant for more than five minutes in the hot dry atmosphere of a summer day. The balance used was an excellent one of Berlin make, permitting of accurate weighing to the one-tenth of a milligramme. Both it and the weights used were subjected to a careful examination as to adjustment beforehand.

Three or four pieces of the fused chlorid of lithium were placed in the platinum crucible used for weighing, the cover was put on, and then the vessel was heated for some time to a temperature not much below the fusing point of the salt. The crucible was cooled over oil of vitriol, weighed, reheated, again cooled, and a second time placed upon the balance, so as to observe perfect correspondence between the two weighings. The fragments of chlorid of lithium were then placed in a beaker of convenient size, and dissolved in water, while the crucible was once more heated, cooled, and weighed; its weight now being subtracted from the former weighing gave the amount of LiCl used. The solution of LiCl was precipitated by a slight

excess of nitrate of silver, the solution gently heated to condense the precipitate, and the latter washed with very dilute nitric acid and then with pure water, first by decantation, and afterwards upon a filter through which all the decanted liquid had been passed. When perfectly washed, the filter with chlorid of silver was carefully dried, and the chlorid of silver transferred as a single lump to a counterpoised porcelain crucible, upon the lid of which the filter was burned, the ashes being moistened with nitric and then with hydrochloric acid. The lid was placed upon the crucible, the latter was heated until the chlorid of silver began to fuse, and was then cooled over oil of vitriol, and weighed.

Two experiments made by the above method gave the following results:—

(1.) 7·1885 grm. of Li Cl gave 24·3086 grm. of Ag Cl.
(2.) 8·5947 grm. of Li Cl gave 29·0621 grm. of Ag Cl.

Now—

24·3086 : 7·1885 : : 1792·94 (equiv. of Ag Cl) : x
x =530·21 (equiv. of Li Cl).
530·21−443·28 (equiv. of Cl)=86·93 = equiv. of Li and
29·0621 : 8·5947 : : 1792·94 : x
x =530·24
530·24−443·28=86·96=equiv. of Li,

the two numbers thus obtained for Lithium agreeing with remarkable closeness.

The difference between these numbers and those of Berzelius and Hagen is however considerable; and as it seemed possible that a little chlorid of sodium still retained in spite of the purification by ether-alcohol might be the cause of this difference, I resolved to precipitate a solution of this supposed pure chlorid of lithium with carbonate of ammonia, to redissolve the carefully washed carbonate of lithia in hydrochloric acid, and, again evaporating to dryness and fusing, to redetermine the chlorine by a slightly different method—namely, that of analysis by measure, as applied by Pelouze to the examination of the atomic weights of sodium and barium.

3·9942 grm. of the chlorid of lithium thus prepared from the carbonate were dissolved in water. 10·1278 grm. of chemically pure silver (the quantity necessary for the precipitation of the chlorine, if Li=89·, and therefore not quite sufficient for the amount of Cl actually present) were dissolved in pure nitric acid, and the two solutions were mixed in a white glass flask. The mixture was gently heated, and shaken until the chlorid of silver had completely separated, leaving the fluid clear. A solution of 1 grm. of pure silver in nitric acid had been prepared, and diluted until the volume=1000 cubic centimeters; 1 c. c. therefore containing ·001 grm. of silver. This solution was now

cautiously added to the fluid in the flask from a pipette furnished with a small glass stop-cock and graduated to the one-fifth of a cub. centim.; the flask being shaken after each addition of the test fluid until the chlorid of silver had completely separated. 42·4 c. c. of this dilute solution of nitrate of silver were needed to complete the precipitation of the chlorine,= ·0424 grm. of silver.

Hence altogether 10·1278+·0424=10·1702 grm. of silver had been used.

10·1702 : 3·9942 :: 1349·66 (equiv. of Ag) : x

x =530·06 (equiv. of LiCl).

530·06—443·28 (equiv. of Cl)=86·78=equiv. of Li.

This number agrees sufficiently nearly with those derived from the two former experiments to show that all three are deserving of confidence. If we take the mean of the three, we shall have the number 86·89 for the equivalent of lithium; and this may, I believe, be fairly trusted as a closer approximation to the truth than any of the numbers hitherto received, if we take into account the greater scale upon which the analyses have been made, and the difference in the methods pursued. For it will be observed that the effect of the difficulty in determining sulphate of baryta already mentioned (namely the adherence of a little of the salt used for precipitation so as to scarcely permit its removal by washing) will necessarily be to increase the apparent per-centage of sulphuric acid in the sulphate of lithia analyzed, and hence to give a *lower* equivalent for the alkali than the true one. But this is the method by which the results hitherto most relied upon have been obtained.

The number 86·89 on the oxygen scale corresponds to 6·95 upon the hydrogen—thus making the equivalent of lithium almost exactly an even multiple of that of hydrogen, in accordance with the analogy which seems to extend further and further through the list of elements, as our knowledge of their atomic weights becomes more exact.

And further, if we take the mean of the equivalents of potassium and lithium, using 86·89 for the latter, we get—

488·86 (Marignac)
86·89

2)575·75

287·87 — almost exactly the equivalent of sodium (287·44) as determined by Pelouze.

Art. XXVII.—*On the Relations of the Fossil Fishes of the Sandstone of Connecticut and other Atlantic States to the Liassic and Oolitic Periods;* by W. C. Redfield.

Read before the American Association at Albany, Aug. 28, 1856.

In the publications of Professor W. B. Rogers and Mr. E. Hitchcock, Jr., on the red sandstone beds of Connecticut, New Jersey and other States, founded on some of the contained fossils, a higher geological position than that of the New Red Sandstone has been assigned to the formation by these writers.* Without questioning their conclusions, I would here observe that the fossil fishes of these rocks are the most characteristic and apparently reliable fossils for determining the age of the formation. The determinative value of these fossils is perhaps enhanced, also, by the small vertical range to which some of the species, and at least one of the genera, are probably limited. But these fishes, although numerous as well as characteristic, do not appear to have been referred to, in any manner, by the above named writers.

Attention is invited, therefore, to a descriptive account of one genus or group of these fishes, which was read to the New York Lyceum of Natural History, in Dec. 1836, by Mr. John H. Redfield, and is found in vol. iv of the "Annals" of that Society. It

* Prof. W. B. Rogers *On the age of the coal rocks of Eastern Virginia*, Am. Jour. of Science, vol. xliii, p. 175, (1842). Also, in Proceedings of the Boston Society of Natural History, vol. v, p. 14, (1854).—E. Hitchcock, Jr., M. D. in Am. Jour. of Science, vol. xx, (N. S.) p. 22, (1855).

Prof. Rogers first assigns to the coal rocks of Eastern Virginia a position near the bottom of the Oolite formation of Europe; while from some fossils "discovered in a particular division of the New Red Sandstone of Virginia," he expects to be able confidently to announce the "existence of beds corresponding to the *Keuper* in Europe,"—doubtless in the extensions of the New Jersey Sandstones or *Newark group*. I propose the latter designation as a convenient name for these rocks, and those of the Connecticut valley, with which they are thoroughly identified by footprints and other fossils, and I would include also, the contemporary sandstones of Virginia and N. Carolina.

At a later period, (1854) Prof. Rogers recognizes the general equivalency of the eastern and middle belts of Virginia, and the eastern or Deep River coal belt of N. Carolina: all of which in his view ought to be placed in the Jurassic series, not far probably above its base. In relation to the more western belt, the occurrence of Posidoniæ, and Cypridæ, in Pennsylvania, with sauroid coprolites and imperfect impressions of *Zamites* leaves, he considers as sufficient to identify, as one formation, the disconnected tracts of this belt, in N. Carolina and Virginia and the prolonged area of the so-called New Red Sandstone of Maryland, Pennsylvania and New Jersey; and that they are of Jurassic date, but little anterior to the coal rocks of Eastern Virginia.

Prof. H. D. Rogers (1839) proposed the name of middle secondary to this group (for convenience sake) to distinguish it from the Appalachian formations on the one hand, and from the green sand deposits on the other.—Third Report on Geol. of Pennsylvania, p. 12.

Mr. Hitchcock describes a new species of *Clathopteris*, discovered in the sandstone of the Connecticut valley. This fossil fern, found near the middle of the series in Massachusetts, he refers to the liassic period.

was founded upon a careful comparison of the genus *Catopterus* with the fossil fishes of different formations in Europe, as these are portrayed in the great work of Prof. Agassiz, then recently received. Such portion of the description and observations then made as relate directly to the geological age of the formation are here quoted.

Of the genus *Cutopterus*, species *C. gracilis*, he says:—"Tail forked, equilobed. Scales extending a little upon the base of the upper lobe." And in regard to the equilobed tail, he adds in a subjoined note:—"This indeed is not *strictly* the case. Its structure, however, is analogous to that of the *Semionotus*, ranked by Agassiz among the *Homocerci*, and differs most decidedly from that of the true *Heterocerci*, where the scales, and probably the vertebræ, extend to the extreme point of the upper lobe." He adds:—

"In the arrangement of Agassiz, this fish would be comprehended in the order *Ganoides*, and family *Lepidoides*. Its equilobed tail would assign it to the second division of the family, the *Homocerci*, as he has termed them. From seven fusiform genera now arranged in this division it is entirely excluded by the posterior position of its dorsal. It may therefore be ranked between the genera *Semionotus* and *Pholidophorus*, being analogous to both in the structure of the tail, and in its serrated fins, and to the latter in the articulation of the rays. From the situation of the dorsal fin I have thought the name *Catopterus* to be applicable to this new genus."—Annals Lyc. Nat. Hist. vol. iv, pp. 38–39.

Nearly twenty years have elapsed since the promulgation of these careful and apparently conclusive observations, which do not appear to have been weakened or set aside by any subsequent researches. It is proper to state that the two analogous genera above mentioned are found in the Oolitic series as well as in the Lias, and it is believed that few, if any of the kindred genera have a lower range.* The above observations afford at least sufficient warrant for the cautious and perhaps too limited

* A single case of semi-heterocercal structure as occurring in the coal rocks of Autun in France, was mentioned to us by Professor Agassiz in 1846. As we learn nothing more of its appearance in the palæozoic series, may there not possibly be an error as regards the authenticity or position of this fish? If otherwise it does not seem to have appeared again until after the Permian period. On the other hand, it appears to be admitted that the true heterocerques, of the *Palæoniscus* type, do not appear above the Trias, and I think they are not found above the Permian.

It should be noted that Sir. P. Egerton has described a most singular fish from the upper strata of the New Red, of a genus hitherto unknown, which has but little inequality in the structure of its caudal base. This fish, the *Dipteronotus cyphus* Eg., is very short and broad, with a double dorsal, and is altogether so *unique* in its character that its occurrence may be deemed to affect but little the chronological inferences which are drawn from the varied structure of the numerous genera and species of the Lepidoid family.—See Geol. Jour. 1854, p. 369, with a figure.

inferences with which Mr. R.'s paper in the Annals is concluded: viz.

"It has of late years been generally admitted that the sandstone from which these fishes are derived is of much later date than the old red sandstone, to which it was once referred, and these remains confirm this belief. The *Palæonisci*, of Europe [true heterocerques] have never been found below the coal measures, while they extend upward to the copper slate of the *zechstein*, or magnesian limestone. In the case before us, we find a species of *Palæoniscus* accompanied by a fish, the structure of whose tail approaches that of the *Pholidophorus*, and of other fishes never found below the lias. This fact would seem to imply for this formation, even a higher situation in the series than that which is now assigned it by geologists."—Annals, &c., p. 40.

The American Association of Geologists and Naturalists at the meeting held in Albany in April, 1843, requested Mr. John H. Redfield to prepare a report on the fossil fishes of the United States. His report was presented to the Association, at New Haven, in May, 1845. It was withheld from publication by its author, on account of the expected visit of Prof. Agassiz to this country, and with a view of commending the whole subject to his examination.—In the review of the fishes of our new red sandstone, so called, the report stated as follows:

"NEW RED SANDSTONE.—Under this term I include the extensive sandstone formation of the Connecticut river valley; the small and isolated basin on the Pomperaug river near Southbury, Ct.; the New Jersey Sandstone, extending from the border of the Hudson river, southwesterly, to the interior of Virginia; and, also, the formation known as the coal rocks of Eastern Virginia.—(Report, p. 4.)

"All of the fishes hitherto found in these rocks belong to the order GANOIDÆ, and to the family LEPIDOIDÆ."—Report, p. 5.

"Prof. Agassiz has made two subdivisions in this, as in other families of the order Ganoidæ, founded on differences in the structure of the tail. In the first of these, (*Heterocerci*) the upper lobe of the tail, is vertebrated and is usually longer than the lower, and the scales of the body extend upon the upper lobe nearly or quite to its extremity. The other division, the *homocerci*, have the tail regular, either forked or rounded, and the scales do not extend upon the upper lobe, though in some genera they are slightly prolonged in that direction. The fishes of our sandstone formation above mentioned, would seem to belong to the first of these divisions, or those with heterocercal tails. They do not, however, exhibit this structure in the same degree which obtains in the fishes of the older European rocks, or even in those of the new red sandstone or magnesian limestone of England and Germany. The only two genera which have yet been

found in our rocks differ somewhat from each other, also, in the degree of heterocercal structure which they present, those species which, following Prof. Agassiz in *P. fultus*, I have allotted to the genus *Palæoniscus*, having the heterocercal structure more decided. But even in these, the tail has a different aspect from the *Palæonisci* of Europe. In the latter, the upper lobe of the tail seems hardly to partake of the character of a fin, and the lower lobe appears to be only a fin-like appendage of the upper, like a second anal fin, while the scales and no doubt the vertebræ extend to the extreme point of the upper lobe."

"The other genus, the *Catopterus* of our rocks, exhibits the heterocercal structure in a still more modified degree. So nearly does it approach in this respect some genera classed as homocercal fishes, such as *Semionotus* and *Pholidophorus*, that in an early memoir published in the Annals of the Lyceum of Natural History, vol. iv, I was led to rank it in that division, subject to a qualifying note. Its relations are however, rather to the heterocercal fishes, or perhaps to an intermediate group."

"This point is an important one in its bearing upon geological questions, for it is now well ascertained that the true heterocercal tail [in the lepidoids] is peculiar to the palæozoic, and lower mesozoic rocks, no fish of that character having been found higher in the series than the triassic rocks, while the true [strict] homocercal tail does not occur below the lias. When therefore we find in the fishes of our sandstone rocks, a structure which seems to be intermediate between the true homocercal and the heterocercal divisions of Agassiz, the conclusion seems irresistible that the including rock *cannot be older* than the triassic, while it must be placed *at least as low* in the series as the lias or oolite." Report, pp. 5–6.

"— Only four species of the genus *Catopterus* are yet known; three of which are found in the red sandstone of New England and New Jersey and the fourth in the coal rocks of Eastern Virginia."* Report, p. 7.

His descriptions of these four species of *Catopterus* are found in the report, and were then prior to any known notice or description of these fishes, other than our own, and together with the descriptions of the more numerous species of the genus *Ischypterus*, are yet withheld from publication, on account of the contemplated arrangements for completing a monograph of the fishes of this formation in the United States.

I have thus shown the examinations and conclusions of Mr. J. H. Redfield on these fishes, as first published in 1837, and as found in his report to the American Association in 1845. In the first of these he points out the age of the containing rocks,

* Others have since been obtained.

and within the same limits which now appear to result from all the subsequent researches.

At the meeting of this Association held in Cincinnati in April, 1851, the present writer made a communication on the Post-Permian character of the red sandstone rocks of Connecticut and New Jersey as shown by their fossils. I then exhibited, together with two species of *Voltzia*, some specimens of the genus *Catopterus* from these rocks, showing the homology of their caudal structure with that of the *Catopterus macrurus* from the coal rocks of Eastern Virginia. This was induced in part by the fact that Sir Philip Egerton, in a paper of Sir Charles Lyell, in the Journal of the Geological Society, had separated this Virginia species from its congeners in the New Jersey and Connecticut rocks, on the ground that the former belonged to the homocercal and the latter to the heterocercal divisions of Prof. Agassiz.* Previous however to this publication of Sir Charles, repeated and careful examinations, with Prof. Agassiz, of the numerous specimens of Catopterus in my possession, collected from the localities of the three different States, had appeared to establish fully their similarity in respect to the structure of the tail. Also, that the *Catopteri* of all the localities, including Virginia, might continue to be referred to the *homocerci*, as in the case of several European genera, or that, more properly both they and the other fishes of these rocks might be referred to a distinct and intermediate division, which is *sub*-heterocercal in its character, if I may so speak. I therefore reclaim the *Dictyopyge* of sir Philip Egerton, founded on my species *C. macrurus*, as still belonging to the genus *Catopterus*. I refer to this matter on the present occasion on account of the important bearing which it has on the geological age of these fishes, as found in the several states.

It may be added in further explanation, that Sir Charles Lyell in the paper referred to, states that "the genus Catopterus was instituted by Mr. Redfield for certain species of heterocercal fish from the Connecticut red sandstone." He seems not to have noticed that the genus was instituted by Mr. J. H. Redfield in 1836 for a *homocercal* fish, according to the characteristics afforded in the *Poissons Fossiles* of Agassiz; and he probably alluded only to my own later notices in this Journal, 1841, vol. xli, p. 27. All the fishes obtained by him from the sandstone of the Connecticut river are also pronounced heterocercal, while the Virginia fish is stated to be homocercal, and this he supports by the opinions of Prof. Agassiz as given on first seeing his specimens

* Sir Charles Lyell *On the Structure and Probable Age of the Coal-Field of the James River, near Richmond, Virginia:* Jour. of the Geol. Soc., vol. iii, 1847, pp. 275–278.

of these fishes in Europe. Based on this designation, Sir Philip Egerton proposed his new genus *Dictyopyge* for the *C. macrurus* of the Virginia rocks.

In regard to the other fishes of New England and New Jersey, Mr. J. H. Redfield had reluctantly followed the work of Prof. Agassiz in assigning them to the genus *Palæoniscus*, although this eminent naturalist had then only seen two imperfect specimens; but Mr. R. then alluded to their structural affinity with the liassic fishes, as we have seen in his conclusion already quoted, and impliedly in the descriptive portion of his paper. It is well seen, also, in his figure of the *P. latus*, attached to his paper in the Annals. In my own notices of 1841, referred to above, I suggested that their less heterocercal forms, and the peculiar structure of their fins warrant their being placed in a separate genus. Sir Philip Egerton recognizes the division, as did Prof. Agassiz in 1846, and Sir Philip proposes for the new genus the name *Ischypterus*.

The question to which of the divisions of Agassiz the Catopterus of Connecticut and this fish of Virginia belong, is simply one of degree. Even if we were to admit a slight difference in this case, it could hardly imply the wide separation which has been claimed. Such a marked division, founded on the structure of the tail, cannot depend on the use of a term, but must be decided by the fishes themselves.

In regard to this point of distinction, may I not quote the matured views of Sir Philip Egerton, so well expressed in the Journal of the Geological Society, 1854, p. 368:—"Although this character, derived from the organization of the caudal fin, is one of great value and significance in the determination of various genera of fossil fishes, it is nevertheless necessary, in drawing general conclusions, to be careful not to assign to it more importance than it is strictly entitled to; for we find, by the comparison of several genera, that it is not one of those well defined trenchant characters which can be affirmed to exist or not, as the case may be, but that it is variable in amount, passing from extreme *heterocercy* to absolute *homocercy* by a sliding-scale so gradual, that it is (at all events in fossil examples) most difficult to define a positive line of demarcation between the two forms."

As the terms have hitherto been used, such line of demarcation, if it exist, appears best indicated at the division between the palæozoic and the mesozoic strata; and perhaps in lesser degree, at the close of the triassic period.

In all our *Catopteri* the scales of the caudal base terminate near the middle rays of the upper lobe, "and not on the upper margin, as in a true heterocerque tail."* Good figures by Din-

* See Egerton as last quoted p. 370.

kel of the species *C. macrurus* of Virginia are given in the above-mentioned paper of Sir Charles Lyell.

It has been seen that Mr. J. H. Redfield considers the other fishes of the Connecticut river and New Jersey rocks as more heterocercal in degree than the Catopterus. In some of the species, however, this difference seems less obvious after a close examination of the structure, than it appears at first view. One or two of the species in my possession I think are even more nearly homocercal than the Virginia fish.

I desire to add, that two of the *Lepidoti* from the table land of India of which figures are given in the Jour. of the Geol. Society, show very strong resemblances to two or three of my fishes from the sandstone of Connecticut river at Sunderland, to one of which I had proposed the name *Ischypterus Marshii.* Is it not probable that the vast extent of sandstone and trap in that distant region, is of like age with our Newark group?

Already I have ventured to state verbally to the Association, that in the valuable collection of fossils from the coal-field of Deep River in North Carolina, now exhibited by Prof. Emmons, I have recognized several well characterized fragments of the genus Catopterus. A close comparison of these with specimens in my cabinet may perhaps show a difference of species. But my present impression is that of identity with one of the New Jersey species.

It would be premature to conjecture how far the new fossils of Prof. Emmons may affect the question of the relative age of these rocks. But when we consider that these fishes evidently belong to fresh water or estuary deposits, as is shown by the entire absence of any remains of large marine fishes, by an almost equal absence of shells, and by the numerous fossilized fragments of vegetation with which the fishes are associated, the chronological evidence afforded by their characteristic organization would seem to be more determinate than that of saurians, plants, or marine fishes, whose general habitat and power of distribution, enable them to occupy a greater range in the geological series.

P. S. It is proper to add, that having now compared the remains of *Catopterus* of Prof. Emmons's collection with my own specimens of the genus, I find them scarcely distinguishable from most of those of the New Jersey and Connecticut rocks. Indeed they appear to be identical with *C. gracilis.* The chief differences appear in the larger size of most of the Carolina specimens which may be due to conditions more favorable to their growth, and in the less flattened condition of the basal portion of the strong and elongate front ray of the pectoral fin,—owing, probably, to a nearly equal pressure on all sides, in the carbonaceous paste or sediment in which they were fossilized.

New York, Sept. 12th, 1856.

Art. XXVIII.—*On the Application of the Mechanical Theory of Heat to the Steam Engine*; by R. Clausius.

[Continued from p. 203.]

27. The influence which the difference of the pressure in the boiler and in the cylinder exerts upon the work, has been treated probably most completely up to this time in the work of de Pambour (Théorie des Machines à vapeur), and I may be permitted before I myself take up the subject, to state in advance the most important points of this mode of treating it, only with a somewhat different notation and with the omission of the magnitudes which relate to the friction, in order to be able the more easily to show how far the theory no longer corresponds to our more recent knowledge of heat, and at the same time to connect with it the new mode of treating the subject, which in my opinion must take its place.

28. The two laws mentioned already at the beginning of this paper, which at that time were pretty generally applied to steam form the foundation of de Pambour's theory. First, the law of Watt, that the sum of the free and latent heat is constant. From this law, the conclusion was drawn, that if a quantity of steam at the maximum density be enclosed in a shell impenetrable to heat, and the cubic contents of this shall be increased or diminished, the steam will in this case be neither over-heated nor partially precipitated, but will remain exactly at the maximum density, and that this would take place quite independently of the mode in which the change of volume may occur, whether the steam had to overcome thereby a pressure corresponding to its expansive force or not. Pambour supposed that the steam behaved in the same way in the cylinder of the steam engine, inasmuch as he did not assume that the particles of water which in this case are mixed with the steam could exert a perceptible changing influence.

In order now to be able more nearly to express the connection which exists for steam at the maximum density, between volume and temperature or volume and pressure, Pambour applied in the second place the laws of Mariotte and Gay Lussac to steam. From these we obtain the equation

$$(28.) \qquad v = 1{,}696 \cdot \frac{10333}{p} \cdot \frac{273 + t}{273 + 100},$$

if we assume with Gay Lussac the volume of a kilogram of steam at 100°, at the maximum density, to be 1,696, and consider that the pressure thereby exerted by one atmosphere upon a square meter is 10,333 kilograms, and if we denote for any other temperature t, the volume and the pressure, assuming the same units,

by v and p. In this equation we need only substitute for p the known values from the tension series, in order to be able to calculate for every temperature the correct volume under these suppositions.

29. As, however, the integral $\int p\,dv$ plays a principal part in the formulas for the work of the steam engine, it was necessary to have the simplest possible formula between v and p alone, in order to be able to calculate this in a convenient manner.

The equations, which we should obtain if we were to eliminate the temperature t from the foregoing equation, by means of one of the empirical formulas for p, would prove too complicated, and Pambour therefore proposed to form a special empirical formula for this purpose, to which he gave, according to the process of Navier, the following general form

$$v = \frac{B}{b+p}, \tag{29}$$

in which B and b are constants. He now sought to determine these constants in such a manner, that the volumes calculated from this formula corresponded as accurately as possible with those calculated from the previous formula. As this however, is not possible with sufficient accuracy for all the pressures which occur in steam engines, he calculated two different formulas, for machines *with* and *without* condensers.

The first is as follows:

$$v = \frac{20000}{1200+p}, \tag{29a}$$

and agrees best with the above formula (28) between $\frac{2}{3}$ and $3\frac{1}{3}$ atmospheres, is applicable however also in a somewhat wider interval, perhaps between $\frac{1}{2}$ and 5 atmospheres.

The second formula determined for machines without condensers, is on the other hand as follows:

$$v = \frac{21232}{3020+p}. \tag{29b}$$

It is most accurate between 2 and 5 atmospheres, and the whole interval of its applicability, extends about from $1\frac{1}{3}$ to 10 atmospheres.

30. The magnitudes depending upon the dimensions of the steam engine which occur in determining the work, shall here be denoted in the following manner, somewhat different from that of Pambour. Let the whole space which becomes free for the steam during a stroke in the cylinder, including the injurious space, be called v'. Let the injurious space form the fraction ε of the whole space, so that thus the injurious space is separated by $\varepsilon v'$ and the space described by the surface of the piston by $(1-\varepsilon)v'$. Further let the portion of the whole space which has become

free for the steam up to the moment of cutting off the cylinder from the boiler, including also the injurious space, be denoted by ev'. Hence the space described by the surface of the piston, during the entrance of the steam will be expressed by $(e-\varepsilon)v'$ and the space described during the expansion by $(1-e)v'$.

In order now, in the first place, to determine the work done, during the admission of the steam, the active pressure in the cylinder during this time must be known. This is, in any event, smaller than the pressure in the boiler, since otherwise no influx of steam would take place; it cannot however be generally stated how great this difference is, since it not only depends upon the arrangement of the machine, but also upon how wide the engineer has opened the valve in the steam pipe, and upon the velocity with which the machine moves. This difference may vary between wide limits by changing these conditions. The pressure in the cylinder also is not necessarily constant during the whole time of the influx, because both the velocity of the piston and the magnitude of the influx opening left free by the steam valve or slide valve are variable.

Pambour assumes with reference to the last condition, that the mean pressure which is to be brought into the calculation in determining the work, can with sufficient accuracy be supposed equal to the pressure which is exerted in the cylinder at the end of the influx, at the moment of cutting off from the boiler. Though I do not consider it advantageous to introduce directly into the general formulas such an assumption, which is made only for the sake of numerical calculation in the absence of more certain data, yet I must here follow his process in setting forth his theory.

Pambour determines the pressure which takes place in the cylinder at the moment of the cut-off by means of the relation established by him between volume and pressure, inasmuch as he thereby supposes that the quantity of steam passing into the cylinder, during the unit of time and consequently also, during one stroke of the piston, is known by special observations. We will as before denote by M the whole mass which enters the cylinder during a stroke of the piston, and that portion of it which is in the form of steam by m. As this mass, of which Pambour only considers the portion which is in the form of steam, fills the space ev' at the moment of the cut-off, we have, if we denote the pressure at this moment by p_2 according to equation, (29)

$$ev' = \frac{m \,.\, B}{b + p_2},$$

whence we have

$$(30.) \qquad p_2 = \frac{m \,.\, B}{ev'} - b.$$

If we multiply this quantity by the space described by the surface of the piston up to the same moment, namely $(e-\varepsilon)\,v'$, we obtain for the first part of the work, the expression:

$$(31.) \qquad W_1 = m\,B\,.\,\frac{e-\varepsilon}{e} - v'\,(e-\varepsilon)\,b.$$

The law according to which the pressure varies during the expression which now follows, is also given by equation (29). Let the variable volume at any moment be denoted by v, and the corresponding pressure by p, and we have

$$p = \frac{m\,.\,B}{v} - b.$$

We must substitute this expression in the integral $\int p dv$ and and then execute the integration from $v=ev'$ to $v=v'$ by which means we obtain as the second part of the work

$$(32.) \qquad W_2 = m\,B\,.\log\frac{1}{e} - v'\,(1-e)\,b.$$

In order to determine the negative work done during the return of the piston, by the counter pressure, the counter pressure itself must be known. Without for the present entering upon the question how this counter pressure is related to the pressure which takes place in the condenser, we will denote the mean counter pressure by p_0, so that the work done by it, is represented by

$$(33.) \qquad W_3 = -\,v'\,(1-\varepsilon)\,p_0.$$

Finally, there still remains the work which must be applied to force the quantity of liquid M, again into the boiler. Pambour has not specially considered this work, but has included it in the friction of the machine. As I have however, taken it into consideration in my formulas, in order to have the cyclus of the operations complete, I will add it here also for the sake of a more easy comparison. If p_1 denotes the pressure in the boiler, and p_0 the pressure in the condenser, this work is represented as a whole by

$$(34.) \qquad W_4 = -\,M\sigma\,(p_1 - p_0),$$

as is deduced from equations (21) and (22) established in the example formerly considered. For our present case, in which we understand by p, not the pressure in the condenser itself, but in the part of the cylinder which is in connection with the condenser. This expression it is true, is not quite accurate; as however in consequence of the smallness of the quantity the whole expression has so small a value that it scarcely deserves consideration, we may neglect the more freely a small inaccuracy in comparison with the small value, and will therefore here also, retain the expression in the same form.

By the addition of these four single quantities of work, we obtain the whole work done during the circular process, namely,

$$(35.)\quad W' = mB\left(\frac{e-\varepsilon}{e} + \log\frac{1}{e}\right) - v'(1-\varepsilon)(b+p_0) - M\sigma(p_1-p_0).$$

31. It is only necessary to divide the foregoing value by m, if we wish finally to refer the work to the unit of weight of steam, instead of to a single stroke of the piston, during which the quantity of steam m is acting. For this purpose, we will denote by b, the fraction $\frac{M}{m}$ which represents the relation of the whole mass which passes into the cylinder, to the portion of it in the form of steam, and which is consequently somewhat greater than 1; furthermore by v the fraction $\frac{v'}{m'}$, that is the space which is offered on the whole to the unit of weight of steam in the cylinder, and by the fraction $\frac{W'}{m}$ or the work corresponding to the unit of weight of steam. Then we have

$$(\text{XII.})\quad W = B\left(\frac{e-\varepsilon}{e} + \log\frac{1}{e}\right) - V(1-\varepsilon)(b+p_0) - l\sigma(p_1-p_0).$$

In this equation, there ocurs only one term which depends upon the volume v, and it contains v as a factor. As this term is negative, it follows that the work which we can obtain by means of the unit of weight of steam, under otherwise equal circumstances, is greatest when the volume which is presented to the steam in the cylinder is the least possible. The smallest value of the volume to which, if we can never quite reach it, we can yet approximate more and more, is that which we find when we assume that the machine moves so slowly, or that the influx pipe is so wide that the same pressure p_1 takes place in the cylinder as in the boiler. This case gives thus the maximum work. If the rate of motion be greater with an equal influx of steam, or if with an equal rate of motion, the influx of steam be less, we obtain in both cases a smaller work by means of the same quantity of steam.

33. Before we proceed from this point to consider the same series of processes in their connection, according to the mechanical theory of heat, it will be advantageous to consider beforehand one of them singly, which still requires a special investigation to fix a priori the results relating to it, namely: the influx of the steam into the injurious space, and into the cylinder, when it has here to overcome a pressure less than that with which it is driven from the boiler. I can proceed in this investigation according to

the same principles which I have already applied to the treatment of several similar cases in a former paper.*

The steam coming from the boiler passes first into the injurious space, compresses here the steam still present from the previous stroke of the piston, fills the space which thereby becomes free, and acts then by pressure against the piston, which, according to our assumption, in consequence of a comparatively small load, yields so quickly that the steam cannot follow fast enough to attain in the cylinder the same density as in the boiler.

Under such circumstances, if only saturated steam passed from the boiler, this would be overheated in the cylinder, inasmuch as the living force of the motion of influx is here converted into heat; as however the steam carries some finely divided water with it, a part of this will be evaporated by the excess of heat, and will thereby retain the remaining steam in a state of saturation.

We must now propose to ourselves the problem: given, the initial condition of the whole mass to be considered, as well that already contained in the injurious space, as also that newly entered from the boiler, further, the quantity of work which is done during the influx by the pressure acting upon the piston, and finally the pressure in the cylinder at the moment of cutting it off from the boiler, it is required to determine how much of the mass in the cylinder is in the state of steam at this moment.

33. Let the mass in the injurious space, before the influx which for the sake of generality shall be assumed to be partly fluid and partly in the form of steam, be called μ, and the portion of it, which is in the form of steam μ_0. The pressure of this steam and the absolute temperature which it possesses may for the present be denoted by p_0 and T_0, without meaning to say that these are exactly the same values which hold good for the condenser also. The pressure and the temperature in the boiler

* *On the behavior of steam in expanding under different circumstances*, these Annals, vol. 82, p. 263. Helmholtz, in his report in the progress of physics, published by the Physical Society of Berlin, for the year 1850 and '51, p. 582, says with respect to this article and a notice connected with it and communicated in the Philosophical Magazine, that in his opinion the same is incorrect in principle, in many points. I have not been able to understand however, the reasons which he assigns for this. Views are ascribed to me which I never had, and propositions expressed in opposition to them which I have never contested, and which form in fact partly the foundation of my own works on the mechanical theory of heat, while the whole is treated in so general a manner that it has been impossible for me to determine how far these views follow from my words or these propositions are to overthrow my conclusions. I do not therefore see myself obliged to defend my former works against this blame. As however, the development which follows here rests as above mentioned, entirely upon the same views by which I was at that time guided, Helmholtz will perhaps find in it also the same errors in principle. For this case, I await his objections, only I would then desire him to go into the matter in a somewhat more special manner.

shall be called as before p_1, T_1, the mass flowing from the boiler into the cylinder M, and the part of it which is in the form of steam m_1. It is not necessary, as already mentioned, that the pressure exerted upon the piston during the influx, be constant. We will call this pressure the mean pressure, and will denote it by p'_1, by which the space described by the surface of the piston during the period of the influx must be multiplied, in order to obtain the same work which is done by the variable pressure. Let the pressure which actually takes place in the cylinder at the moment of the cut-off, be denoted by p_2 and the temperature by T_2, and let finally the quantity, with the determination of which we have to do, namely, the portion of the whole mass now present in the cylinder $M+\mu$, which is in the form of steam, be represented by m_2.

To determine this quantity, let us consider the mass $M+\mu$, in any manner brought back to its initial condition. The vaporized portion m_2, is condensed in the cylinder by the downward pressure of the piston, whereby it is supposed that the piston can also penetrate into the injurious space. Let at the same time so much heat be in any manner withdrawn from the mass, that its temperature T_2 remains constant. Then the portion m_1 of the whole fluid mass is pressed back into the boiler where it again assumes the original temperature T_1. The same condition is thereby restored in the boiler as before the influx, inasmuch as it is of no importance whether exactly the same mass, m_1 which was previously in the form of steam, is so now again, or whether an equally large other mass has taken its place. The remaining portion μ is first cooled down, in the fluid condition from T_2 to T_0, and at this temperature the portion μ_0 is converted into steam, by which the piston moves so far that this steam can again assume its original space.

34. The mass $M+\mu$, has consequently gone through a complete circular process, to which we may now apply the theorem that the sum of all the quantities of heat taken up by the mass, during a circular process, must be equivalent to the whole external work performed in it. The following quantities of heat are taken up, one after another.

1. In the boiler, where the mass M is heated from the temperature T_2 to T_1, and the portion m_1 must be converted into steam at the latter temperature:

$$m_1 r_1 + Mc(T_1 - T_2).$$

2. During the condensation of the portion m_2 at the temperature T_2:

$$- m_2 r_2.$$

3. During the cooling of the portion μ from T_2 to T_0:

$$- \mu c (T_2 - T_0).$$

4. During the evaporation of the portion μ_0, at the temperature T_0:

$$\mu_0 r_0.$$

The whole quantity of heat which may be called Q, is consequently:

(36.) $$Q = m_1 r_1 - m_2 r_2 + Mc(T_1 - T_2) + \mu_0 r_0 - \mu c(T_2 - T_0).$$

The quantities of work are found in the following manner:

1. In order to determine the space described by the surface of the piston during the influx, we know that the whole space occupied by the mass $M+\mu$, at the end of this time, is

$$m_2 u_2 + (M+\mu)\sigma.$$

From this the injurious space must be subtracted. As this was filled in the beginning at the temperature T_0 for the mass μ, of which the portion μ_0 was in the form of steam, it may be expressed by

$$\mu_0 u_0 + \mu\sigma.$$

If we subtract this quantity from the previous one and multiply the remainder by the mean pressure, p'_1, we obtain as the first work:

$$(m_2 u_2 + M\sigma - \mu_0 u_0) p'_1.$$

2. The work, by the condensation of the mass m_2, is:

$$-m_2 u_2 p_2.$$

3. By forcing back the mass m into the boiler

$$-M\sigma p_1.$$

4. By the evaporation of the portion μ_0:

$$\mu_0 u_0 p_0.$$

By the addition of these four quantities, we obtain for the whole work W, the expression,

(37.) $$W = m_2 u_2 (p'_1 - p_2) - M\sigma(p_1 - p'_1) - \mu_0 u_0 (p'_1 - p_0).$$

If we substitute these values of Q, and W, in equation (1), namely,

$$Q = A \,.\, W$$

and bring the terms containing m_2 together on one side, we have

(XIII.) $$m_2[r_2 + Au_2(p'_1 - p_2)] = m_1 r_1 + Mc(T_1 - T_2) + m_0 r_0 - \mu c(T_2 - T_0) + A\mu_0 u_0 (p'_1 - p_0) + AM\sigma(p_1 - p'_1).$$

By means of this equation, we can calculate the quantity m_2 from the quantities supposed to be known.

35. In those cases in which the mean pressure p'_1 is considerably greater than the final pressure p_2, for instance, if we assume that during the greater part of the period of influx, nearly the same pressure has taken place in the cylinder as in the boiler, and that the pressure has first diminished to the lesser value p_2, by the expansion of the steam already in the cylinder, it may happen that we find for m_2 a value which is smaller than $m_1 + \mu_0$, that consequently a portion of the steam originally present is precipitated. If on the other hand, p'_1 be but little greater or in fact smaller than p_2, we find for m_2 a value which is greater than $m_1 + \mu_0$. This last is to be considered as the rule in the steam engine, and holds good in particular also for the special case assumed by Pambour that $p'_1 = p_2$.

We have consequently arrived at results which differ essentially from Pambour's views. While he assumes one and the same law for the two different kinds of expansion which occur in succession in the steam engine, according to which the steam, originally present neither increases nor diminishes, but always remains exactly at a maximum density, we have found two different equations, which permit us to recognize an opposite relation. According to the equation just found (XIII), new steam must still arise in the first expansion during the influx, and in the further expansion, after the cutting off from the boiler, whereby the steam does the full work corresponding to its expansive force, a portion of the steam present must be precipitated according to the equation (VII) already developed. As these two opposite actions of increasing and diminishing the steam, which must also exert a contrary influence upon the quantity of work done by the machine, partly counteract each other, the same final result may occur approximately under certain circumstances, as according to Pambour's more simple assumption. We must not however, therefore neglect to take into consideration the difference found, particularly when we desire to determine in what manner a change in the arrangement, or in the working of the steam engine, acts upon the quantity of its work.

36. By the help of the quantities of heat cited singly in § 34, we may according to what is stated in § 8, easily determine the uncompensated transformation which occurs during the expansion, by applying the integral which occurs in the equation

$$N = -\int \frac{dQ}{T}$$

to these quantities of heat.

The communication of the quantities of heat $m_1 r_1 - m_2 r_2$ and $\mu_0 r_0$, occurs at constant temperatures, namely T_1, T_2, T_0, and these portions of the integral are therefore:

$$\frac{m_1 r_1}{T_1}, \quad -\frac{m_2 r_2}{T_2} \text{ and } \frac{\mu_0 r_0}{T_0}.$$

For the portions of the integral arising from the quanties of heat $Mc(T_1 - T_2)$ and $-\mu c(T_2 - T_0)$, we find, according to the process already applied in § 23, the expressions:

$$Mc \log \frac{T_1}{T_2} \text{ and } -\mu c \log \frac{T_2}{T_0}.$$

By putting the sum of these quantities in the place of the above integral, we obtain for the uncompensated transformation, the value:

$$(38.) \quad N = -\frac{m_1 r_1}{T_1} + \frac{m_2 r_2}{T_2} - Mc \log \frac{T_1}{T_2} - \frac{\mu_0 r_0}{T_0} + \mu c \log \frac{T_2}{T_0}.$$

37. We may now return again to the complete circular process which takes place during the working of the machine, and

consider as before the particular portions of the same in succession.

The mass M flows from the boiler in which the pressure p_1 is assumed, into the cylinder, the part m_1 as steam, and the remainder as liquid. Let the mean pressure acting in the cylinder during this time be denoted as above by p'_1, and the final pressure by p_2.

The steam now expands until its pressure has sunk from p_2 to a given value, p_3 and consequently its temperature from T_2 to T_3. The cylinder is thereupon put into communication with the condenser in which the pressure p_0 is exerted and the piston makes the whole motion just completed again in the opposite direction. The counter pressure which it thereby undergoes, is during a somewhat more rapid motion greater than p_0, and we will therefore, to distinguish it from this value, denote the mean counter pressure by p'_0.

The steam which remains at the end of the motion of the piston in the injurious space, which must be considered for the next stroke, is under a pressure which in like manner need be neither equal to p_0 nor p'_0 and may therefore be denoted by p''_0. It may be greater or smaller than p'_0 according as the cutting off from the condenser takes place somewhat before or after the end of the motion of the piston, inasmuch as the steam in the first place is compressed somewhat further, in the last case, on the contrary, has time to expand somewhat more by the partial influx into the condenser.

Finally the mass M must be brought back from the condenser into the boiler, whereby as before the pressure p_0 acts to produce the effect and the pressure p_1 must be overcome.

38. The quantities of work done in these processes are represented by expressions quite similar to those in the simpler case already considered, only that the indices of the letters are changed in a manner which is easily understood, and the quantities which relate to the injurious space must be added. We thus obtain the following equations:

For the period of influx according to § 34, in which however u''_0 must be written instead of u_0.

$$(39.) \qquad W_1 = (m_2 u_2 + M\sigma - \mu_0 u''_0) p'_1.$$

For the expansion from the pressure p_2 to the pressure p_3, according to equation (IX) if $M+\mu$ is put in the place of M:

$$(40.) \quad W_2 = m_3 u_3 p_3 - m_2 u_2 p_2 + \frac{1}{A}[m_2 r_2 - m_3 r_3 + (M+\mu) c (T_2 - T_3)]$$

For the return of the piston, in which the space described by the surface of the piston is equal to the whole space occupied by the mass $M+\mu$ under the pressure p_3, less the injurious space represented by $\mu_0 u''_0 + \mu\sigma$.

$$(41.) \qquad W_3 = -(m_3 u_3 + M\sigma - \mu_0 u''_0) p'_0.$$

For the forcing back of the mass M into the boiler:

$$(42.) \qquad W_4 = -M\sigma(p_1 - p_0).$$

The whole work is therefore:

$$(43.) \quad W' = \frac{1}{A}[m_2 r_2 - m_3 r_3 + (M+\mu)c(T_2 - T_3)] + m_2 u_2 (p'_1 - p_2)$$
$$+ m_3 u_3 (p_3 - p'_0) - M\sigma(p_1 - p'_1 + p'_0 - p_0) - \mu_0 u''_0 (p'_1 - p'_0).$$

The masses m_2 and m_3 which occur herein may be found from equations (XIII) and (VII), in which it is only necessary to substitute in the first the value p''_0 in the place of p_0 to change in corresponding manner the quantities T_0, r_0 and u_0, and to introduce in the last the sum $M+\mu$ in the place of M. I will not, however, here completely execute the elimination of the two quantities m_2 and m_3 which is possible by these equations, but will only substitute its value for one of them m_2, because it is more advantageous for calculation to consider the equation so obtained together with the two already determined. The system of equations which serves to determine the work of the steam engine, is therefore in its most general form:

XIV.
$$\begin{cases} W' = \frac{1}{A}[m_1 r_1 - m_3 r_3 + Mc(T_1 - T_3) \\ \quad + \mu_0 r''_0 - \mu c(T_3 - T''_0)] + m_3 u_3 (p_3 - p'_0) \\ \quad + \mu_0 \mu''_0 (p'_0 - p''_0) - M\sigma(p'_0 - p_0). \\ m_2[r_2 + Au_2(p'_1 - p_2) = m_1 r_1 + Mc(T_1 - T_2) + \mu_0 r''_0 - \mu c(T_2 - T''_0) \\ \quad + A\mu_0 u''_0 (p''_1 - p''_0) + AM\sigma(p_1 - p'_1) \\ \quad \frac{m_3 r_3}{T_3} = \frac{m_2 r_2}{T_2} + (M+\mu)c \log \frac{T_2}{T_3}. \end{cases}$$

(To be concluded.)

Art. XXIX.—*Examination of the Meteoric Iron from Xiquipilco, Mexico;* by W. J. Taylor.*

The meteoric iron from Xiquipilco, Mexico, appears to have been first mentioned in the Gazeta de Mexico in 1784. It is stated there that small pieces of native iron, from a few ounces to fifty pounds in weight were very numerous, which were sought for by the Indians after heavy rains, who used them for manufacturing agricultural implements.

In a dissertation on metallic meteorites by Prof. W. S. Clark, the following notices of its literature are given:—Ann. des Mines Ser. 1, t. 2, p. 337. Gazeta de Mexico, 1784–5, vol. i., pp. 146, 200. Klaproth Beiträge zur chemischen Kenntniss der Mineral Körper, B. 4, s. 101. Sonnenschmit, Beschriebung der vorzug-

* From the Proceed. Acad. Nat. Sci. of Philadelphia, vol. viii, No. 3.

lichsten Bergwerke. Reviere de Mexico 1804, p. 192 and 288. Chladni (U. F. M. S. 336) Partsch, (D. M. S. 99.)

In the examination made by M. Berthier he failed to detect the presence of cobalt, but it is mentioned by Prof. Clark that Manross had found it in a specimen from the cabinet of Prof. Wöhler; my examination confirms that of Mr. Manross.

To the kindness of W. S. Vaux, Esq., I am indebted for the material for this investigation; Mr. Vaux has in his magnificent cabinet the principal portion of a mass which weighed over ten pounds. It was originally about six inches long, with an average diameter of three inches; the lump was oblong with rounded ends, the whole being covered with a thin crust of limonite.

A cross section cut from this lump has been carefully polished and etched by strong nitric acid, which gives a most beautiful surface of about three and a half inches in length, by two and a half in breadth, covered with the greatest complexity of widmannstattian figures which almost defy description.

The surface is crossed by bands about one-tenth to one-sixteenth of an inch in breadth; these apparent bands are cross sections of different planes, as is readily perceived by their different refractive powers.

On changing the position of the specimen, those that are a bright silvery white in one direction, become a dull grey in another, and vice versa.

There are several systems of bands, which preserve a parallelism among themselves and cross other systems at various angles, forming trapezoids, rhombs and triangles. These several fields and their characteristic etchings will be described in detail at some future time. Along the bands or planes, thin laminæ of schreibersite have been observed, as in other meteoric irons.

Imbedded in one side of the large lump (just described) was a globule of pyrrhotine, which looks as if it had been dropped into the iron when it was in a semi-fluid state. This globule appears to have been about an inch in diameter: it was in part decomposed; but a small portion of the mineral was separated sufficiently pure for the determination of its specific gravity and analysis. On dissolving it in hydrochloric acid, thin laminæ of schreibersite separated with minute portions of chromic iron.

Through the kindness of Dr. F. A. Genth, I have been permitted to make the following analysis in his laboratory:

Pyrrhotine dissolved in nitric acid, gave—

No. 1.	Sulphur,	33·76	per cent.
	Iron,	57·95	"
	Nickel,	6·70	"
	Cobalt,	·56	"
	Silicon,	·05	"
	Phosphorus,	·25	
		99·27	"

No. 2 dissolved in hydrochloric acid, gave

Iron, - - - - 58·25 per cent.

A residue remained, which dissolved after being treated with hydrochloric acid and chlorate of potash: it consisted of

Copper, - - - - 0·12 per cent.

The remainder consisted principally of chromic iron, with a small portion of schreibersite.

The specific gravity was found to be 4·822.

The ratio of sulphur to the metals was found to be

Sulphur, 2·102,	Iron,	2·066,	2·301.
	Nickel and Cobalt,	0·245,	

It will be seen that the composition corresponds with that of pyrrhotine, considering its formula to be FeS, if we disregard the few impurities which were found with it.

The meteoric iron was first treated in a flask with hydrochloric acid, and the gas evolved was passed through a solution of ammonia chlorid of copper, but not a trace of sulphur could be detected in this manner.

In the fifth supplement to Rammelsberg's Handwörterbuch der chemischen Mineralogie, this meteoric iron is mentioned as passive, experiments having been made by Prof. Wöhler; but the piece belonging to Mr. Vaux is evidently active, throwing down metallic copper from a neutral solution of its sulphate. This experiment was repeated with great care with confirmatory results.

No. 1 was dissolved in hydrochloric acid, and a slight precipitate was obtained by hydrosulphuric acid, which on a careful examination before the blowpipe, was found to be copper with a trace of tin.

Iron, - - - - -	90·72	per cent.
Nickel, - - - - -	8·49	"
Cobalt, - - - - -	·44	"
Schreibersite, Chromic iron, &c.,	·38	"
Silicon, - - - - -	·25	"
Phosphorus, - - - -	·18	"
	100·46	

The phosphorus was estimated in a separate portion which was first oxydized by nitric acid and fused in a platinum crucible with carbonate of soda.

No. 2 was dissolved in nitric acid.

It gave,	Iron,	90·37	per cent.
	Nickel,	7.79	"
	Insoluble residue,	1·91	"
		100.07	

ART. XXX.—*On the Heat in the Sun's Rays*; by ELISHA FOOTE.

(Read before the Amer. Association for the Advancement of Science, Aug. 23, 1856.)

THE experiments here detailed were instituted for the purpose of investigating the heat in the Sun's rays.

Two instruments have been used for this purpose. One was Leslie's differential thermometer. Both bulbs of it were blackened by holding them in the smoke of burning pitch. When experimenting one was shaded, the other was exposed to the direct action of the sun's rays; and as both were thus equally subject to all other influences, the result was not affected by them.

Generally, however, I have found it more convenient to use two mercurial thermometers, and note their difference. Two small and very delicate instruments were procured as nearly alike as possible. The stems of both were attached to the same plate about two inches apart, and the scales were marked upon it in juxtaposition, so that the eye could see the indications of both at the same time. Both bulbs were blackened as in the other instrument. It was used in the same manner. The temperatures in the sun and in the shade were noted, and their difference was taken as equivalent to the indications of the differential thermometer.

The question that first arises is, does the difference between the shaded and exposed bulbs afford a correct measure of the heat in the sun's rays? To this point I would ask attention before proceeding to the experiment.

The theory of the differential thermometer was accurately investigated by Leslie. In one of the foci of two parabolic reflectors he placed a tin canister which was heated or cooled by putting in liquids of different temperatures or frigorific mixtures. In the other, the heat was received on one of the bulbs of his differential thermometer: and under all circumstances, the indications of the instrument were found to be accurately proportional to the differences between the temperatures of the canister and those of the surrounding air.

I have varied these experiments by keeping the canister at the uniform heat of boiling water in different temperatures of the air, and by substituting other sources of heat, and have always found the results to accord with those obtained by the distinguished philosopher to whom I have referred.

The principles of radiation lead to the same result; for while the differential thermometer receives heat from the canister, it at the same time radiates it to surrounding bodies, and that in pro-

portion or nearly so to the difference between its temperature and that of the medium in which it is placed.

I regard it therefore as well established that the differential thermometer affords a correct measurement of the *differences* between the heat of the canister and that of the surrounding air. These differences may evidently be varied in two ways: by changing either—

1st. The heat of the canister ; or—

2dly. The temperature of the air.

An increase or diminution in the heat of the canister would directly increase or diminish the differences; whilst an increase in the temperature of the air would diminish the difference until an equality between the two was obtained. If the temperature of the air were uniform and the changes were those of the canister alone, the instrument measuring the differences would correctly indicate those changes. But if the heat of the canister were uniform and that of the air were varied, then would the instrument equally indicate those changes, but in a contrary direction. In case the heat of both the canister and the air was varied at the same time, if we knew the change in one and its effects upon the instrument, we could *easily* deduce the changes in the other. Suppose, for example, an increase of ten degrees on the scale of the instrument and an elevation of five degrees in the temperature of the air ; the effect of the latter having been to depress the thermometer five degrees, and the canister having not only overcome that effect but increased the indications ten degrees, the sum of the two or fifteen degrees would be the real change which had taken place in the heat of the canister. Had there been a depression in the temperature of the air, it obviously should be subtracted from the indications of the instrument to obtain the desired measurement.

It is upon these principles that I have applied the differential thermometer to measure the comparative heat in the sun's rays. One of its bulbs received their direct action in the same way that it received the rays proceeding from the canister. The temperature of the air was at the same time obtained by a common thermometer. An increase was added to, and a diminution subtracted from, the indications of the instrument to obtain the real changes in the heat of the rays proceeding from the sun.

My first experiment was of the simplest kind. It was a winter's day. The differential thermometer was placed on the outside of a window where the temperature was below the freezing point. The effect measured by the scale (which merely divided the stem into equal parts) was 53°. It was then placed on the inside of the window where the temperature was about 70°, and to my surprise the effect rose to 115°. The experiment was many times repeated with similar results, although varying

some in amount from the different degrees of brightness in the sun. The change in the temperature of the air was still to be added, and the conclusion seemed to be irresistible, that the sun's rays in passing into the heated room acquired a temperature that they did not derive from the sun.

The experiment was next repeated with different temperatures of the room, and it was found that the intensity of the rays depended upon the heat of the room. Indeed in the coldest weather in winter I could impart to them a power which belonged to a summer's sun.

At a later period when the circumstances were changed and the heat on the outside had become greatest, the indications of the instrument were reversed. The high temperature of the summer rays was in a great measure lost or dissipated on entering into a cool room. There they had no greater power than had been found at similar temperatures in the winter.

For the purpose of a more accurate investigation of the subject, I procured a glass shade or receiver about ten inches in diameter and twenty-two in height. A copper base was adapted to it with a groove around the outer edge into which the receiver fitted; and when it was filled with dry ashes the point was thereby rendered sufficiently air-tight. It was supported by legs so high that a spirit lamp could be placed under it, and any required temperature given to the air within.

A second receiver of the same size was sometimes used for the purpose of simultaneous comparison. The air within it was cooled by inserting a tin canister filled with frigorific mixtures. The thermometers were supported within the receivers, and thus at the same time the same rays could be tested in the opposite extremes of temperatures.

I subjoin, as an example, the following table (p. 380) containing the results of an experiment made in February last, at eight o'clock in the morning. It was a clear day and the sun shone through a window into the room where the instruments were placed.

The first observation was the temperature of the room and in the sun upon a mercurial thermometer. The lamp was placed under the receiver, and as the temperature of the air was gradually increased, the effect was noted until the heat in the sun had attained the highest limit of the thermometer. The fourth column contains the differences between the thermometer in the shade and the one in the sun. The fifth column shows the true relative heat of the sun's rays at the different temperatures. It was obtained as before explained by adding to the differences the increase in the temperature of the air. Several observations may be made in regard to the results in the table.

No. of obs.	Temp. of air.	Temp. in sun.	Diff.	Relative heat of sun's rays.
1	40	46	6	6
2	44	50	6	10
3	48	56	8	16
4	50	60	10	20
5	54	66	12	26
6	58	70	12	30
7	63	80	17	40
8	70	90	20	50
9	78	100	22	60
10	83	106	23	66
11	88	110	22	70
12	98	120	22	80
13	102	124	22	84
14	108	130	22	90

1st. That the heat in the sun's rays is not uniform, such as would proceed from a great heated body of uniform intensity, nor is it such as was received from the canister, when kept at the same degree of heat, but that it varies and is dependent upon the temperature of the air.

2ndly. That the effects of the sun's rays upon the thermometer at the different degrees of heat in the receiver is the same that has usually been observed at similar temperatures in the open air. It is easy by changing the heat within the receiver, to imitate the power of the sun's rays that has been observed at any time or in any place; indeed at the same time, the same rays may have in one receiver the burning heat of a summer's sun, and in the other only the feeble action of winter.

3dly. It appears that heat does not travel along with the rays of light as has been usually supposed, but that it is received, or parted with, lost or acquired, according to the temperature of the place that the rays illuminate. The same rays that within the receiver have the high intensity belonging to summer, on passing to the outside, are reduced again to a winter's temperature.

In view of these results it seems to me to accord better with the facts to attribute to the sun's rays, perhaps to all light, an action of some kind on such heat as they come in contact with, producing thereby the effects that we have been accustomed to attribute to an enormous temperature in the sun. Each planet may be supposed to possess its own atmosphere of heat: this will be affected by the sun's light as the heat within the receiver was affected; but they need not be frozen by their great distance, nor burned by their near approach to the great luminary.

It becomes an interesting and important enquiry, to ascertain the circumstances that affect the action of light on heat.

One of the most obvious is, that the amount of action depends upon the quantity of light. The clearness of the atmosphere always affects the experiment, making it somewhat difficult to compare observations taken at different times. A strong light obtained by reflection or otherwise, always increased the

effect. But the most striking results were obtained by concentrating the rays with a lens. One was placed in the receiver with its focus directed upon an additional thermometer, the second and third columns in the following table contain the temperatures of the air and in the sun, and the fourth, the heat in the focus, while the air in the receiver was heated as before. The atmosphere at the time was not entirely clear.

No. of obs.	Temp. of air.	Temp. in sun.	Heat in focus.
1	76	82	104
2	78	88	114
3	80	90	120
4	84	96	130
5	90	102	138
6	100	110	148
7	104	114	152

The burning glass was then so arranged that being within the receiver its focus was on the outside. The result was as follows:

No. of obs.	Temp. of air.	Temp. in sun.	Heat in focus.
1	44	50	60
2	51	60	60
3	58	68	62
4	62	72	62
5	73	83	60
6	96	106	58

Then the burning glass was placed on the outside of the receiver and so arranged that its focus should be on the inside, and the effect was the same as if both glass and focus had been on the inside.

It will be observed that the effect of the burning glass is simply to increase the results before obtained. Its power depends upon the temperature of the place at which the light is concentrated. That no heat travels with the light is rendered more manifest. The increased temperature of the rays on the inside had no effect at their focus on the outside.

The power of the burning glass seems therefore to depend on two considerations: 1st, the amount of light concentrated, 2ndly, the amount of heat on which it acts.

Those who have heretofore sought its best effects have, it seems to me, too much neglected the latter consideration. Its greatest power is to be obtained by concentrating the greatest amount of light on the highest degree of artificial heat. The combination of the two may perhaps have important practical applications. The chemist may possibly produce new results by adding to the highest resources of artificial heat the powerful agency of concentrated light.

The subject is unfinished, and it is my intention to resume it on some future occasion.

Art. XXXI.—*Circumstances affecting the Heat of the Sun's Rays;* by Eunice Foote.

(Read before the American Association, August 23d, 1856.)

My investigations have had for their object to determine the different circumstances that affect the thermal action of the rays of light that proceed from the sun.

Several results have been obtained.

First. The action increases with the density of the air, and is diminished as it becomes more rarified.

The experiments were made with an air-pump and two cylindrical receivers of the same size, about four inches in diameter and thirty in length. In each were placed two thermometers, and the air was exhausted from one and condensed in the other. After both had acquired the same temperature they were placed in the sun, side by side, and while the action of the sun's rays rose to 110° in the condensed tube, it attained only 88° in the other. I had no means at hand of measuring the degree of condensation or rarefaction.

The observations taken once in two or three minutes, were as follows:

Exhausted Tube		Condensed Tube.	
In shade.	In sun.	In shade.	In sun.
75	80	75	80
76	82	78	95
80	82	80	100
83	86	82	105
84	88	86	110

This circumstance must affect the power of the sun's rays in different places, and contribute to produce their feeble action on the summits of lofty mountains.

Secondly. The action of the sun's rays was found to be greater in moist than in dry air.

In one of the receivers the air was saturated with moisture—in the other it was dried by the use of chlorid of calcium.

Both were placed in the sun as before and the result was as follows:

Dry Air.		Damp Air.	
In shade.	In sun.	In shade.	In sun.
75	75	75	75
78	88	78	90
82	102	82	106
82	104	82	110
82	105	82	114
88	108	92	120

The high temperature of moist air has frequently been observed. Who has not experienced the burning heat of the sun that precedes a summer's shower? The isothermal lines will, I think, be found to be much affected by the different degrees of moisture in different places.

Thirdly. The highest effect of the sun's rays I have found to be in carbonic acid gas.

One of the receivers was filled with it, the other with common air, and the result was as follows:

In Common Air.		In Carbonic Acid Gas.	
In shade.	In sun.	In shade.	In sun.
80	90	80	90
81	94	84	100
80	99	84	110
81	100	85	120

The receiver containing the gas became itself much heated—very sensibly more so than the other—and on being removed, it was many times as long in cooling.

An atmosphere of that gas would give to our earth a high temperature; and if as some suppose, at one period of its history the air had mixed with it a larger proportion than at present, an increased temperature from its own action as well as from increased weight must have necessarily resulted.

On comparing the sun's heat in different gases, I found it to be in hydrogen gas, 104°; in common air, 106°; in oxygen gas, 108°; and in carbonic acid gas, 125°.

ART. XXXII.—*Review of a portion of the Geological Map of the United States and British Provinces by Jules Marcou*;* by WILLIAM P. BLAKE.

GEOLOGICAL maps of the United States published in Europe and widely circulated among European geologists, are necessarily regarded by us with no small degree of attention and curiosity. This is more especially true, when such maps embrace regions of which the geography has only recently been made known and the geology has never before been laid down on a map with any approach to accuracy.

The recent geological map and profile by M. J. Marcou, which has appeared in the Annales des Mines and in the Bulletin of

* Carte Géologique des Etats-Unis et des Provinces Anglaises de l'Amérique du Nord par Jules Marcou. *Annales des Mines*, 5e Série, T. vii, p. 329. Published also with the following:

Résumé explicatif d'une carte géologique des Etats-Unis et des provinces anglaises de l'Amérique du Nord, avec un profil géologique allant de la vallée du Mississippi aux côtes du Pacifique, et une planche de fossiles, par M. Jules Marcou *Bulletin de la Société Géologique de France*. Mai, 1855, p. 813.

the Geological Society of France, presents us, in addition to the geology of the Atlantic States, a view of the geology of the broad and comparatively unknown region between the Mississippi and the Pacific. Representing regions which have not been visited by the person making it, such a map is necessarily a work of compilation, inference and generalization, and in the present state of our knowledge, some errors are to be expected. I will not undertake to say how far the author has faithfully used the means in his power for making a good geological map, but as there are errors too important to pass unnoticed, I will simply point out those which are most glaring and most likely to mislead foreign geologists. I shall confine myself solely to the western part beyond the Mississippi.*

Commencing on the Pacific coast, the peninsula of San Francisco is represented as composed of erupted and metamorphic rocks, being colored the same as the Sierra Nevada and Appalachians. The rocks of that peninsula, and on both sides of the Golden Gate, are chiefly sandstone and shale, and the same formation extends along the shores of the Bay to and beyond San José. Not only the extent and position, but the lithological characters of these rocks are discussed in a published report,† which was in the hands of the author of the map previous to its publication. The representation of the granitic rocks is not confined to the end of the peninsula, but is continued southward to the western shores of the Tulare lakes where the formations are chiefly miocene tertiary, the eruptive rocks scarcely appearing.

The promontory called Point Pinos, which forms the headland of the Bay of Monterey, is represented as tertiary, while a porphyritic granite constitutes the whole point and forms the coastline south to the Bay of San Carlos, and is probably continuous southward to San Luis Obispo; forming a high and unbroken line of coast, all of which is colored tertiary on the map. Casting the eye further south, we find the color denoting the eruptive and metamorphic rocks again usurping the place which should be colored tertiary, at Point Conception, which consists of beds of conglomerate and sandstone.

The broad alluvial tract at the head of the Gulf of California —the Colorado desert—is made to extend nearly due north and parallel with the Colorado to the Soda Lake. The published description of this valley gives its direction as northwest and southeast, extending to the foot of San Bernardine Mountain.

* A former map by M. Marcou, published at Boston a little over two years since, was reviewed in vol. xvii, of this Journal. The present map is in part open to the same criticisms.

† Preliminary Geological Report on the Pacific Railroad Route, surveyed by Lieut. R. S. Williamson in California, House Doc., 129, Washington, D. C., Jan. 1855.

The extensive coal-fields of Puget Sound and the Coast of Oregon are represented as *Upper* Carboniferous or of the true coal-period. All the evidence which can be procured concerning the age of these deposits shows them to be Tertiary. The resemblance of the sandstone found with the coal to that of San Francisco, and the presence of *Pectens* in it has been noticed in published reports. Observations by Prof J. S. Newberry reported since the publication of the map show that these coal-deposits are undoubtedly Tertiary.*

In the region of the Wind River mountains, a range called the Black Hills, extending northeast of the Platte, has found a place in most of our maps. We find the geological structure of this range indicated on the map, as granitic and carboniferous, while on another map published in Gotha, it is represented as composed of cupriferous trap. A recent exploration of that region by Lieut. G. K. Warren, U. S. A., shows that this range is purely imaginary and should not appear on the maps north of the Platte.

According to the map, the region of the South Pass is occupied by a belt of cupriferous trap, extending over at least two degrees of longitude, and in a northeast and southwest direction, with the same trend as Keweenaw point and Isle Royale, Lake Superior. There is no record of any such outcrops as this in any of the reports of explorers who have visited that region. Fremont, Stansbury and others, found horizontal sedimentary formations resting on granitic rocks.†

The Wind River range, which according to Col. Fremont and his collection, is granitic and metamorphic, trending north-westerly, is not represented on the map. Fremont's peak, however, the highest peak of the range, and described by Fremont as composed of granite, gneiss, syenite, and syenitic gneiss, is represented as a *volcano*. The Raton Mountains are also colored as volcanic; in Abert's Report they are described as sedimentary, and coal-plants were obtained there and figured in the report.‡

These, however, are but inconsiderable errors when compared with the representation of the geological age of the strata forming the broad table lands on each side of the great central chain of mountains. These are represented as *Jurassic* above and *Triassic* below. The Jurassic forms a conspicuous feature on the map and includes the Llano Estacado, and all the table-lands from the Missouri to the Rio Grande. It is surrounded by a

* Proceedings of the American Association for the Advancement of Science, Albany, 1856.

† See the descriptions of the collections by Prof. James Hall, and report of Col. J. C. Fremont, p. 295.

‡ Report of an Examination of New Mexico, by Lieut. J. W. Abert, U. S. Top. Engineers, 1848

much broader coloring representing the trias. Yet there is no sufficient evidence of the presence of Jurassic formations, and the Llano and other plateaux referred to that age are not Jurassic, but Cretaceous.

The evidence brought forward to show the presence of the Jurassic, consists of one species of *Gryphæa* and one of *Ostræa*. They were obtained from the upper strata of Pyramid Mount—one of the mounds separated from the Llano Estacado by erosion. The Gryphæa is said to have the greatest analogy with *G. dilatata* of the Oxford clay of England and France, and was provisionally called *G. Tucumcarii*. The Ostræa is reported to bear much resemblance to *O. Marshii* of the inferior Oolite of Europe.* In the text accompanying the map the species are announced as identical, one with *G. dilatata*, the other with *O. Marshii*. Even if this identity be admitted, it does not authorize the conclusion that the strata are beyond question Jurassic; or if it did, the occurrence of Jurassic at that one point on the Canadian, would not authorize us to conclude that the formation extends for more than a thousand miles on both sides of the mountains. The genus Gryphæa in America is eminently characteristic of the Cretaceous formation, and species which very closely resemble *G. Tucumcarii*, if not in fact identical with it, are very abundant in Alabama and New Jersey in the Cretaceous formation. Moreover, all the species are found with many variations according to the locality. The abundance and variety of the species of this genus render it unsafe to regard *G. Tucumcarii*, however much it may resemble *G. dilatata*, conclusive evidence of the presence of oolitic formations. Specimens of the Gryphæa are found in the government collection, but there are none of the Ostræa.

Some of the evidences of the Cretaceous age of the Llano may now be presented. If we follow the strata in which the *Gryphæa* was procured, westward, we find them extending across the mountain chain, through the passes, into the valley of the Rio Grande, and here near the summit of the table-lands just south of Santa Fé, Mr. Marcou reports the presence of Cretaceous fossils. Farther west, at Poblazon near the Puerco, Lieutenant Abert obtained several specimens of *Inoceramus*† from horizontal strata. The topography at this point is the same as along the valley of the Canadian, the strata are at nearly the same elevation, and their mineral characters are similar. Numerous specimens of *Inoceramus* have also been obtained by Simpson,‡

* See Resumé of a Geological reconnoissance, &c. Report of Lieut. A. W. Whipple, U. S. Top. Engrs., H. Doc. 129, chap. vi.

† Described and figured by Prof. Bailey—Report by Lieut. J. W. Abert, U. S. Top. Engrs. of an Examination of New Mexico.

‡ Report aad Map of the Route from Fort Smith, Arkansas, to Santa Fé, by Lieut. J. H. Simpson, U. S. Top. Engrs., Washington, 1850.

Wislizenus and others along the valley of the Canadian river not far from Pyramid Mount, where the *Gryphæa* was procured. Farther east on the False Washita and near the Canadian, the Cretaceous fossil *Gryphæa Pitcheri* occurs in abundance and near the great beds of gypsum. Leon Spring, in the southern part of the Llano, has afforded abundance of Cretaceous fossils, and this place is represented on the map as Jurassic. Cretaceous fossils were also obtained by Capt. Pope from the bluffs of the Llano at the Sulphur Springs of the Colorado and from the surface of the plateau near the Sand Hills.* The Llano of Texas is well known and is undoubtedly the continuation of the Llano Estacado. The bluffs are filled with Cretaceous fossils already described by Ferdinand Rœmer. They are correctly represented as Cretaceous on the map.

The map displays a most remarkable relation of position between the Cretaceous and the "Jurassic" along the valley of the Rio Grande between El Paso and the mouth of the Pecos. The river has cut its valley downwards through the horizontal formations of the Llano which form bluffs on each side. On the map we find the valley of the stream colored as Cretaceous, while the higher strata of the Llano, are colored as Jurassic. Thus, according to this representation, the Jurassic strata overlie the Cretaceous. This conclusion is unavoidable unless we are ready to believe that the Cretaceous strata were deposited since the erosion of the valley of the Rio Grande. The same alternative is presented to us along the Upper Missouri; the highest table-land is colored as Jurassic, and the Cretaceous is made to crop out lower down nearer the river and rests directly upon the formation called Trias.

But the most striking feature of the map remains to be noticed. We find an area equal to that of all the States east of the Mississippi colored as Triassic. The section also represents this formation as enormously thick, and with four divisions corresponding to those in Europe. The color is extended on the map along the whole course of the Missouri down to Council Bluffs, and south into Texas, and is carried east so as to reach and border the southern shore of Lake Superior. The basis of this representation is chiefly the occurrence of red gypseous strata along the False Washita and Canadian rivers. The upper limit of the formation is considered to be at the base of the so-called Jurassic strata of the Llano, and its lower upon the Carboniferous.

The representation of this broad area as Triassic is made without the evidence of a single characteristic fossil, the principal support for it being the position and mineral characters of the strata. It is said that they are like those of Windsor and Plaister Cove, N. S., which were supposed to be Triassic but have since been shown by Mr. Dawson to be Carboniferous.† Hence the

* Report on the Geology of the Route surveyed by Bvt. Capt. Pope, U. S. Top. Engrs., 4to. Washington, 1856. [Pacific R. R. Exp. and Surveys.]

† Acadian Geology, by J. W. Dawson. Edinburgh, 1855.

similarity indicates a Carboniferous age rather than Triassic. The limit of the formation above or below, although perhaps well defined at one point, may not be at others, or may be very different; the red color of the strata—the only guide—being the result of chemical changes and not of original deposition. The lower limit is not clearly defined, and there are no outcrops or uplifts of the strata sufficient to reveal the whole series. The thickness, therefore, cannot be accurately stated.

The entire absence of fossils from these strata, so far as known, and our slight knowledge of the line of separation between them and those of known age, and the impossibility of determining their thickness, render it premature, at least, to assign them to the age of the Trias, and to partition them into groups corresponding to those of the formation in Europe. We may with equal reason call the strata Jurassic, Liassic, Triassic and Permian, or either of them, as Triassic alone. It would be most in accordance with the indications to refer them to the Cretaceous and Carboniferous, the two adjacent formations above and below.

But even if the gypseous strata along the Canadian were proved to be of Triassic age, it does not follow that those along the Upper Missouri, a thousand miles away, are of the same period. According to published reports the strata along the river are Cretaceous, and there is no evidence of the presence of the Trias. Neither is there any evidence of the extension of the Lake Superior sandstone across Wisconsin into Iowa and out to the Missouri, as if the formation occupied an east and west valley in the granite. Such a representation is at variance with published records, and these surely should be regarded in the absence of personal observation. It is hardly necessary to state that the sandstone of Lake Superior has been examined by three separate geological corps,—Messrs. Whitney and Foster with the assistance of Prof. James Hall, by D. D. Owen, and by Sir W. E. Logan of Canada—and after several years of exploration in that region, all arrive at the conclusion that the sandstone is not the New Red, but is the equivalent of the Potsdam sandstone of New York. Prof. James Hall has announced the conclusion also in a notice of a former map by Mr. Marcou.

There is here a disregard of published results and an audacious attempt at generalization which has seldom been equalled. The fact that Mr. Marcou's map is widely circulating in Europe just such American Geology as this, has made it the duty of the science of the country to protest against its being accepted abroad, notwithstanding its publication under the sanction of the Geological Society of France.

Art. XXXIII.—*On New Fossil Corals from North Carolina;* by E. Emmons. (From a letter to one of the Editors.)

The fossils which I herewith transmit for your examination occur in Montgomery Co., N. C. I regard them as the oldest organic bodies yet discovered. But that you or your readers may be furnished with facts upon which they may form their opinions, I will state the relations of the masses in which they are found both with the inferior primary series, and the overlying rocks which immediately succeed the beds in which they are found.

1. Talcose slates in connexion with granite or gneissoid granite.

2. Brecciated conglomerate from 300 to 400 feet thick. Parts of this mass are porphyrized.

3. Slaty breccia associated with chert or hornstone.

4. Granular quartz, which is in part vitrified and filled with this fossil and with siliceous concretions, which are about the size of almonds. It is 250–300 feet thick.

5. Slaty quartzite, its fossils much less numerous. It is 40 feet thick.

6. Slaty sandstone without fossils, 50 feet.

7. White quartz, more or less vitrified, filled with fossils and almond-shaped concretions.

8. Jointed granular quartz, similar to that of Berkshire Co., Mass., with only a few fossils.

9. Vitrified quartz without fossils, 30 feet thick.

10. Granular quartz, no fossils, thickness great, but undetermined.

11. Overlying these siliceous beds is a clay slate like that so common in Rensselaer and Columbia Cos., N. York. As yet, it has yielded me no fossils. The slate as a whole, remains unchanged, but frequently contains vitrified beds, or silicified ones, the origin of which I do not propose to speak of at this time.

1*a* 1*b* 1*c*

It is evident the fossil is a coral. Among the specimens I think I can recognize two species. The generic name which I have given it is *Palæotrochis*, "*Old Messenger*," the smaller is the *P. minor* (fig. 1), the larger, *P. major*, fig. 2.

2a

2b

Form lenticular and circular, and similar to a double cone, applied base to base; surfaces grooved; grooves somewhat irregular, but extend from the apices to the base or edge. Apex of P. minor provided with a rounded excavation, the opposite with a rounded knob. The description it will be perceived applies to the three smaller figures or *P. minor.*

The reproduction of the coral seems to take place invariably upon the common edge of the double cone. A germ bud, or a young one, appears on the edge of fig. 1*a*. The multiplication of similar buds produces a change of form, as represented in fig. 1*c*, where the edge appears strongly grooved, or double. The middle figure shows the rounded depression, the right hand one, the knob.

It is worthy of notice that as the cones are dissimilar, but meet together at the edge spoken of, this edge becomes the plane of reproduction. I do not know however, but germs are also formed in the grooves, but the coral is constantly undergoing a change of form, by the production of germs upon the edge. The individuals are very numerous, the rock being composed almost entirely of them, intermixed with concretions, for 600 or 700 feet in thickness.

The debris of this fossiliferous sandstone has been worked quite successfully for gold. The metal is contained in ferruginous masses, in the rock which appears to have been an auriferous pyrites. Over $100,000 have been procured by pulverizing and washing this material which also very frequently contains the Palæotrochis.

Albany, September 10, 1856.

ART. XXXIV.—*Description of an Isopod Crustacean from the Antarctic Seas, with Observations on the New South Shetlands;* by JAMES EIGHTS.—With two plates.

[IT is a fact of interest in the geographical distribution of animals, that the largest number of species of the group of Tetradecapods (the 14-footed Crustacea), and those also of the largest size, are found, not in the tropics, but in the temperate and frigid zones. Among *known* species, the ratio for the tropics and extratropics, as I have shown, is 150 : 530, or over three times as many occur in the extra-tropics as in the tropics. In my memoir on the Geographical Distribution of Crustacea, I have stated that out of the 49 recognized genera of Isopods, only 19 occur in the tropics; of 20 genera of Anisopods, only 6 occur in the tropics; and out of the 50 genera of Gammaridea, only 17 contain tropical species. Among the Isopods, the tribe of Idotæidea is especially numerous in cold-water seas; the ratio of extra-tropical to tropical species being 8 : 1; and *two-ninths* of the extra-tropical belonging to the *frigid* zone. Moreover the frigid or subfrigid zone affords the largest of known Idotæidæ, one or more of them three to four inches in length, while the tropical species hardly exceed an inch. The *Glyptonotus* of Eights, from the New South Shetlands, is one of these giant species, the length of his specimen being 3½ inches. It therefore takes the lead among Isopods, and even among all Tetradecapods, and derives thence a peculiar interest. It was described in the 2nd volume of the Albany Institute, and represented by two fine plates engraved by Mr. J. E. Gavit. Through the kindness of Mr. Gavit we are allowed the use of the plates, and therefore here republish the description of Dr. Eights. It is not clear that the genus Glyptonotus is actually distinct from the older one of Idotæa. Yet it will probably be sustained on the ground of the form of the head, the character of the abdomen, and perhaps the distinctive peculiarities of the 6 anterior legs. Part of the characters mentioned in the description are involved in the fact of its belonging to the Tetradecapoda. Still we cite it entire, as published.

The same volume of Transactions of the Albany Institute (pp. 58–69,) contains Remarks by the same author on the New South Shetland Islands, from which we make citations, after giving the description of the Crustacean.—J. D. D.]

GENUS GLYPTONOTUS, *Eights.*

Animal composed of a head, thorax, and post-abdomen, constituting in all thirteen distinct segments.

Head deeply inserted into the cephalic segment of the thorax. *Eyes* sessile, and finely granulate. *Antennæ* two pairs, placed

one above the other, with an elongate multiarticulated filament. *Mouth* as in the ordinary *Isopods;* mandibles not palpigerous; the two superior foot-jaws expanded into a well defined lower lip, bearing palpi.

Thorax separated into seven distinct segments, the three posterior ones biarticulate near their lateral extremities; each segment giving origin to a pair of perfect legs, terminating with a strong and slightly curved nail.

Post-abdomen, or tail, divided into five segments, provided with neither styles nor natatory appendages; the under surfaces each supporting a pair of branchial leaflets, longitudinally arranged, and covered by two biarticulated plates attached to the outward edges of the last segment, closing over them much in the manner of an ordinary bivalve shell.

Species G. Antarctica.—Animal perfectly symmetrical, ovate, elongate, and depressed. Teguments solid and calcareous. Color, brown sepia. Length, from the insertion of the antennæ, three and a half inches; width, one and three-quarters.

Head traversely elliptical, terminating at its lateral and anterior margin obtusely elevated, aud arched each way to its centre.

Superior surface of the head ornamented with an imperfectly sculptured "fleur-de-lis;" posterior portion obtusely elevated, producing a marginal rim. *Eyes* small, reniform, indigo blue, and placed near the lateral and anterior portion of the head, so deeply impressed in the margin of the shell as to be easily distinguished from beneath. Inferior pair of *antennæ* longer than the superior, corresponding in length to the width of the head, transversely, from spine to spine; articulations four in number; last segment longest, the remaining three gradually diminishing in length as they proceed to the place of insertion; segments triangulate, with angular projections on their surfaces; edges of the angles, and articulating extremities rigidly spined. Terminating filament about the length of the basal articulations, gradually attenuated until it diminishes to a finely pointed apex. Superior *antennæ* half the length of the inferior, three-jointed, and terminating with an attenuated filament whose articulations are indistinct; segments angular, external one much the longest; extremities and angles likewise spined. *Mouth* with the labrum or upper lip hard and massive, resembling in form a reversed heart. The mandibles are without palpi, stout and osseous, tipped with a hard and black enamel. The maxillæ are furnished with the usual palpi. The lower lip, or superior foot-jaws when united, sub-cordate; its palpi five-jointed, snugly embracing the manducatory organs along their base, like a row of ciliated leaflets.

The *thorax* is composed of seven distinct segments, each one being beautifully ornamented on its superior surface by an elon-

gated and sub-conic insculptation, forming a series, whose pointed apices almost unite along the longitudinal dorsal ridge. These segments are finely bordered along their posterior articulating edges by an elevated and continuous marginal rim, extending to the lateral extremities of the shell. The cephalic depression is likewise margined by an obtusely elevated border. Each segment of the thorax gives origin, beneath, to a pair of ponderous angulated legs, composed of the ordinary parts. The three anterior pairs project themselves forward, and are closely compressed upon the inferior surfaces of the three foremost segments; they are monodactyle, with the nails incurved upon the anterior edges of the rather largely inflated penultimate joint. Each joint is furnished at its articulating extremity with rigid spines; the inner edges of the penultimate joint, together with those of the three adjoining, are provided with a double row of tufted ciliæ, disposed diagonally, and much resembling in appearance the arrangement of hairs in an ordinary brush. The four posterior pairs of legs are directed backwards, strongly triangulate, stout and ponderous, terminating by a slightly curved nail; their length is nearly equal, but they gradually increase in thickness as they recede toward the tail. The basal joints are large and inflated; the remainder regularly angulate. The extremities of the articulating joints, and edges of the two inferior angles, are each provided with a series of tufted and rigid spines.

The *post-abdomen* is composed of five segments. The four anterior ones are much smaller than those which constitute the thorax, but greatly resemble them in form, being ornamented on their superior surfaces with similar insculptations, though but slightly defined. Each of these segments is provided beneath with a pair of articulated pedicels, which furnish a support to the bifoliated branchial leaflets. These leaflets are arranged longitudinally one upon the other, and are entirely concealed by the biarticulated plates of the caudal segment; they are suboviate and elongate: the outer ones smaller than those which they cover, and are nearly surrounded by a fringed cilia, most conspicuously developed along their inner margins. The second pair are each supplied with an elongated style, extending almost to the termination of the caudal segment. The terminating segment is large and triangular, giving attachment to the biarticulated plates at a single point on its outer margins near the base, which enables the animal to close them together in a line along its centre beneath. These plates are about the length of the segment, and of a triangulate form, each one having near its termination a small oval articulation. The segment and marginal plates are slightly inflated along their external edges, producing an obtusely elevated border.

The segments constituting the thorax and post-abdomen are supplied by a central, angular, and elongated knob, which, when united, form a prominent dorsal ridge, gradually diminishing in its backward course, and forming a sharp elevated line along the caudal segment, terminating at its extremity in a short and obtusely pointed spine.

This beautiful crustacean furnishes to us another close approximation to the long lost family of the Trilobite. I procured them from the southern shores of the New South Shetland Islands. They inhabit the bottom of the sea, and are only to be obtained when thrown far upon the shores by the immense surges that prevail when the detached glaciers from the land precipitate themselves into the ocean.

Extracts from the Remarks of Dr. Eights on the New South Shetlands.

After landing at several places along the coast and spending some days at Staaten Land, we proceeded to the new South Shetland Islands, whieh are situated between 61° and 63° of south latitude, and 54° and 63° west longitude. They are formed by an extensive cluster of rocks rising abruptly from the ocean, to a considerable height above its surface. Their true elevation cannot easily be determined, in consequence of the heavy masses of snow which lie over them, concealing them almost entirely from the sight. Some of them however rear their glistening summits to an altitude of about three thousand feet, and when the heavens are free from clouds, imprint a sharp and well defined outline upon the intense blueness of the sky: they are divided everywhere by straits and indented by deep bays, or coves, many of which afford to vessels a comfortable shelter from the rude gales to which these high latitudes are so subject.

The shores of these islands are generally formed by perpendicular cliffs of ice frequently reaching for many miles, and rising from ten feet, to several hundred in height. In many places at their base, the continued action of the water has worn out deep caves with broadly arched roofs, under which the ocean rolls its wave with a subterranean sound that strikes most singularly on the ear; and when sufficiently undermined, extensive portions crack off with an astounding report, creating a tremendous surge in the sea below, which as it rolls over its surface, sweeps everything before it, from the smallest animal that feeds on its shallow bottom, to those of the greatest bulk. Entire skeletons of the whale, fifty or sixty feet in length, are not unfrequently found in elevated situations along the shores many feet above the high water line, and I know of no other cause capable of producing this effect. Whales are very common in this vicinity.

The rocks are composed principally of vertical columns of basalt, resting upon strata of argillaceous conglomerate; the pillars are united in detached groups, having at their bases sloping banks constructed of materials which are constantly accumulating by fragments from above. These groups rise abruptly from the irregularly elevated plains, over whose surface they are here and there scattered, presenting an appearance to the eye not unlike some old castle crumbling into ruin, and when situated upon the sandstone promontories that occasionally jut out into the sea, they tower aloft in solitary grandeur over its foaming waves; sometimes they may be seen piercing the superincumbent snow, powerfully contrasting their deep murky hues with its spotless purity. Ponds of fresh water are now and then found on the plains, but they do not owe their origin to springs, being formed by the melting of the snow.

The rocky shores of these islands are formed of bold craggy eminences standing out into the sea at different distances from each other, from whose bases dangerous reefs not unfrequently lie out for several miles in extent, rendering it necessary for navigators to keep a cautious watch, after making any part of this coast: the intervals between these crags are composed of narrow strips of plain, constructed of coarsely angulated fragments of every variety of size, which at some previous period have fallen from the surrounding hills. They slope gradually down to the water terminating in a fine sandy beach: a few rounded pieces of *granite* are occasionally to be seen lying about, brought unquestionably by the icebergs from their parent hills on some far more southern land, as we saw no rocks of this nature in situ on these islands. In one instance, I obtained a bowlder nearly a foot in diameter from one of these floating hills. The action of the waves has produced little or no effect upon the basalt along this coast, as its angles retain all the acuteness of a recent fracture, but where the conglomerate predominates, the masses are generally rounded.

The color of the basalt is mostly of a greenish black. The prisms have from four to nine sides, most commonly however but six, and are from three to four feet in diameter; their greatest length in an upright position above the subjacent conglomerate is about eighty feet. Their external surfaces are closely applied to each other, though but slightly united, and consequently they are continually falling out by the expansive power of the congealing water among its fissures. When they are exposed to the influence of the atmosphere for any length of time, they are for a small depth of a rusty brown color, owing no doubt to the iron which they contain becoming partially peroxydized: sometimes they are covered by a thin coating of quartz and chalcedony.

Clusters of these columns are occasionally seen reposing on their side in such a manner as to exhibit the surfaces of their base distinctly, which is rough and vesicular. When this is the case they are generally bent, forming quite an arch with the horizon. Where they approach the conglomerate for ten or twelve feet, they lose their columnar structure and assume the appearance of a dark-colored flinty slate, breaking readily into irregular rhombic fragments: this fine variety in descending gradually changes to a greenish color and a much coarser structure, until it passes into a most perfect amygdaloid, the cavities being chiefly filled with quartz, amethyst and chalcedony. Sometimes an interval of about forty or fifty feet occurs between these columns, which space is occupied by the amorphous variety elevated to some considerable height against them; their edges in this case are not at all changed by the contact.

The basis rock of these islands, as far as I could discover, is the conglomerate which underlies the basalt. It is composed most generally of two or three layers, about five feet in thickness each, resting one on the other and dipping to the southeast at an angle of from twelve to twenty degrees. These layers are divided by regular fissures into large rhombic tables, many of which appear to have recently fallen out, and now lie scattered all over the sloping sides of the hills, so that the strata when seen cropping out from beneath the basalt, present a slightly arched row of angular projections of some considerable magnitude and extent.

These strata are chiefly composed of irregular and angular fragments of rock, whose principal ingredient appears to be green earth, arranged into both a granular and slaty structure, and united by an argillaceous cement; the whole mass when moistened by the breath giving out a strong argillaceous odor. The upper portion of this conglomerate for a few feet, is of a dirty green color, and appears to have been formed by the passage of the amygdaloid into this rock, the greenish fragments predominating, and they are united to each other principally by a zeolite of a beautiful light red or orange color, together with some quartz and chalcedony; a few crystals of lime cause it to effervesce slightly in some places. These minerals seem in a great measure to replace the earthy cement. In descending a few feet farther, the green fragments gradually decrease in number and become comparatively rare, the minerals also give place to the cement until the whole mass terminates below in a fine argillaceous substance, with an imperfect slaty structure and a spanish-brown aspect.

This rock being much softer in its nature than the basalt and more affected by decomposing agents, the number of fragments are consequently greater in proportion, and much more finely

pulverised, forming the little soil which supports some of the scattered and scanty patches of vegetation on these islands.

The minerals embraced in this rock are generally confined to its upper part where it unites and passes into the incumbent amygdaloid, and many of them are also in common with that rock. They consist chiefly of quartz, crystalline and amorphous, amethyst, chalcedony, cacholong, agate, red jasper, felspar, zeolite, calcareous spar in rhombic crystals, sulphate of barytes, a minute crystal resembling black spinelle, sulphuret of iron and green carbonate of copper.

The only appearance of an organized remain that I anywhere saw, was a fragment of carbonized wood imbedded in this conglomerate. It was in a vertical position, about two and a half feet in length and four inches in diameter: its color is black, exhibiting a fine ligneous structure, and the concentric circles are distinctly visible on its superior end; it occasionally gives sparks with steel, and effervesces slightly in nitric acid.

There are a number of active volcanoes in the vicinity of these islands, indications of which are daily seen in the pieces of pumice found strewed along the beach. Capt. Weddel saw smoke issuing from the fissures of Bridgeman's island, a few leagues to the northeast. Palmer's land is situated one degree south: what little is known of it, which is only a small portion of its northern shore, contains several. Deception island also one of this group, has boiling springs, and a whitish substance like melted feldspar exudes from some of its fissures. * * * *

ART. XXXV.—*Description of a large Bowlder in the Drift of Amherst, Massachusetts, with parallel striæ upon four sides;* by Professor EDWARD HITCHCOCK.

IN grading one of the streets in Amherst last year, the surface of a large bowlder, or ledge, in front of the residence of Hon. Edward Dickinson, was brought to light, on which numerous rather fine but distinct striæ were exhibited, whose direction corresponds essentially with that taken by the drift agency in this region, viz., south a few degrees east. This fact led me to suspect the rock to be the top of a ledge: but on probing the earth around, I found it to be a bowlder. The present summer I proposed to my class in Geology, (which is the Junior Class in College), to dig around the specimen, and try to remove at least the top of it to the vicinity of the Geological Cabinet, about half a mile distant, where it might serve as a fine example of striæ to future classes. They promptly engaged in the enterprise, and on digging around the specimen, found it to be of an oblong

shape, the four longest sides being nearly at right angles to each other, while the ends were more irregular. Its medium length was 6½ feet; its breadth, 5½ feet; and its thickness, 2¾ feet. Consequently its weight was about eight tons. It was determined to raise it out of its bed; and when this was done, I was surprised to find the striæ more distinct upon the bottom than anywhere else. They were more minute upon the perpendicular sides than on any other part, though these sides were perhaps the most perfectly smoothed. But on all sides they were essentially parallel, although upon the top there were at least two sets, making a small angle with each other, as is common upon surfaces striated by the drift agency.

I had never met with a bowlder of this description. Its unique character awakened an ambition in the class to remove it entire. I doubted their ability to do this: but young men are strong, and in this case they were very skillful also; for although much of the way is ascending, they went through the work successfully, and without accident; and in a single day they planted the bowlder in front of the Wood's Cabinet on a slope, sustaining the lower end by portions of two large trap columns from Mount Tom, so that the visitor can look beneath and see the striæ there. It stands in the same position as originally, except that the ends are inverted. Deeply engraved upon one end are the words,—"*The Class of* 1857;" that being the year when they graduate.

This rock is a fine-grained hard reddish sandstone, such as occurs on the west face of Mettawampe, (Mt. Toby,) a mountain lying nearly north of Amherst, ten miles distant, and from which the bowlder was undoubtedly derived.

How now shall we explain the parallel striation on four sides of this bowlder? Striated blocks I believe, have generally been regarded as having been frozen into an iceberg, or a glacier, which grated along the surface. But this explains the striæ only on one side. For if the bowlder should happen to have been frozen into a second iceberg, or glacier, how small a chance would there be, that it would be scratched in a parallel direction on a second side. Far less is the probability that a third side would have been striated in the same direction; and almost infinitely less the chance that a fourth side would have experienced a like dressing. Should a bowlder be frozen four times into a mass of ice, how almost certain that the striæ would run in different directions. We must, therefore, give up the idea that this bowlder was scratched in the manner usually assigned.

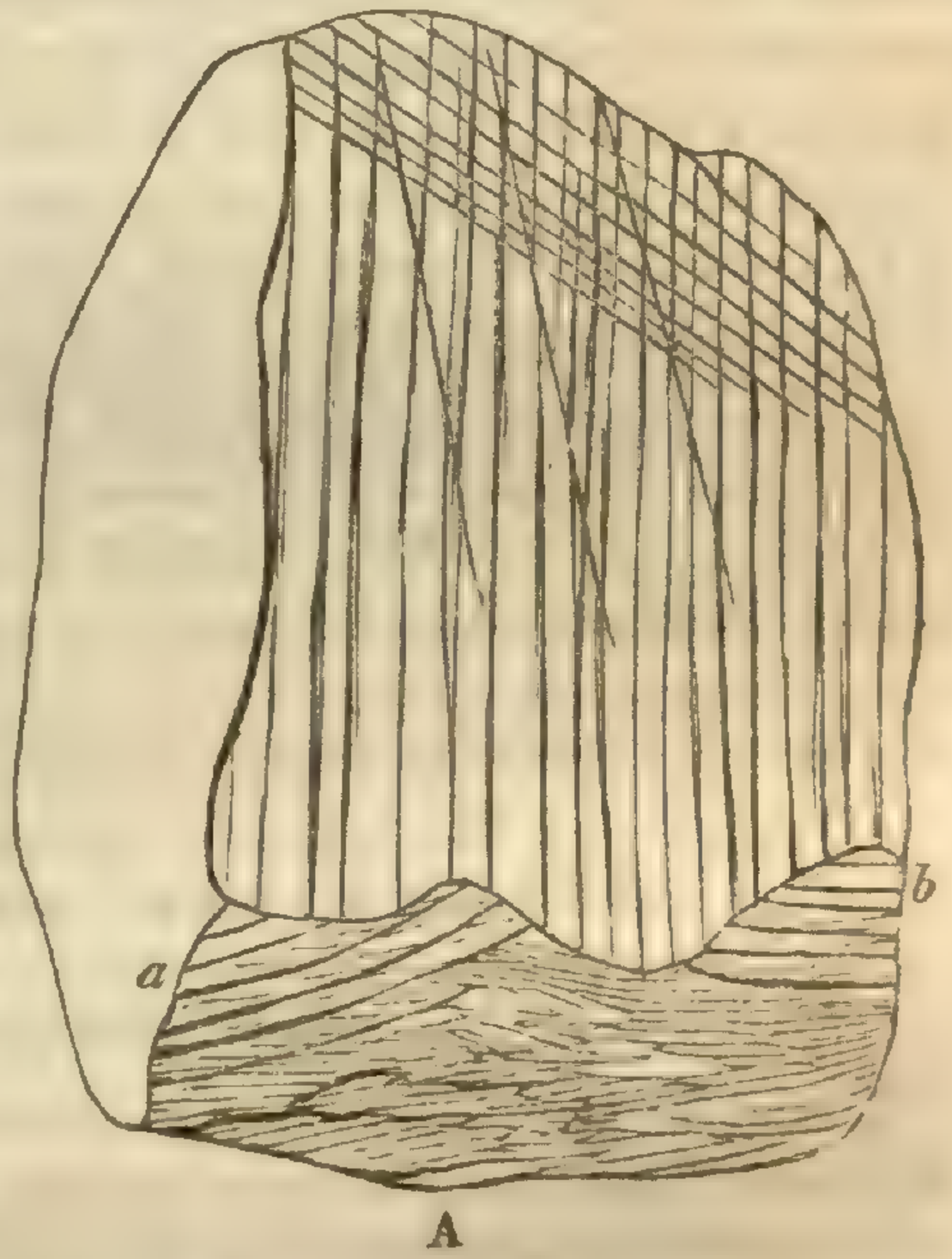
But suppose that when it started from Mettawampe on its southern journey, it were frozen into the bottom of an iceberg. As this grated over the rocky surface, it would soon be smoothed and striated: nor is it strange that in such a manner the erosion

and grooving should be deeper, and the edges less rounded, (as they are) than by what I suppose to have been the subsequent processes.

There is another way in which this striation of the bottom might have been accomplished. It might have been done while yet the bowlder was a part of the ledge from which it was broken. In that case it must have been turned over after starting from its bed.

A third method may be suggested for this work. After the bowlder got mixed up with other fragments, and a strong *vis a tergo*, either aqueous or glacial, was pushing them all forward, so large a block as this might have pressed so heavily upon the surface as to be deeply furrowed.

That a strong force was exerted upon the bowlder to urge it forward, is obvious from a fact respecting the end of it, (A) lying towards the north (now the south end), as shown by the annexed outline. Both ends appear for the most part as if acted upon chiefly by water, being irregularly rounded and smoothed, but not furrowed, except in two places, *a* and *b*. Near the middle, the top, as may be seen, projects a foot or so, and on each side the surface is striated by lines running upwards, as if smaller bowlders had struck against it, and not being able to move it, were forced over it.



A

If a strong current were thus crowding detritus against and over the bowlder, its oblong form would keep its longer axis in the same direction as the stream. Hence the smaller fragments forced against and over it, would smooth the top and the sides in the same direction. They would press most heavily upon the top, and accordingly the striæ are much deeper there than upon the sides, though it should also be recollected that the edge of a stratum is usually harder than its face.

I impute the parallel striation of this bowlder, then, first to its great weight, which caused smaller fragments to slide over it more or less; and secondly, to its oblong form, which kept it nearly in the same position while advancing.

The only striæ on this bowlder not yet described, are a few faint ones running obliquely across the present north end, (the

south end as it lay originally). Most of these I presume are simply the marks of vehicles, which, for the whole spring, passed over this part of the bowlder, and I was surprised to find that they made so slight an impression. I think, however, that among these wagon tracks I can see one or two produced by some other agency; and it is not improbable that during its rough transportation, bowlders might have been forced over it in that direction.

I have regarded the detritus collected along the central part of Amherst, where this bowlder lay, as *Modified Drift:* that is, coarse drift that has been subsequently acted upon, and more or less rounded and sorted by water. Generally the fragments at this place are more rounded and of less size than we see in the coarse drift upon the neighboring hills, and yet the bowlders are considerably larger, though the one now described is much the largest I have seen in our modified drift.

As this bowlder seems to me to be of unusual interest, and is now placed permanently, through the energy and scientific zeal of the class of 1857, where geologists can examine it, I have thought this description might be acceptable to the readers of the Journal. At any rate, it has been the means of qualifying one College Class, as they wander over the world, to examine striated bowlders and ledges.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the wave lengths of the most refrangible rays of light in the Interference Spectrum.*—EISENLOHR has contributed a very interesting paper upon the wave lengths of the invisible rays, which he has determined by means of the diffraction spectrum, essentially in the manner employed by Schwerd. The author in the first place describes his method of projecting the phenomena of diffraction upon a screen. A ray of light is introduced horizontally into a dark room by means of a heliostat and allowed to fall upon a narrow vertical slit or other opening placed at a distance of one meter. From 4 to 12 meters behind this slit an achromatic object-glass of 3 meters focal length is placed in a round hole in a board, the plane of which is at right angles to the incident ray. Disks with lattices of different kinds may be fastened immediately in front of the object-glass; a white or transparent screen is placed at a proper distance behind the lens. The image of the slit must be distinctly projected upon this screen before the lattice is fastened in front of the object-glass. In this manner, spectra of extraordinary size and beauty are obtained, particularly when the openings are very narrow and numerous. All the phenomena of diffraction described by Schwerd in his classical work may in this way be represented so that they may be seen by a number of

persons at once. The author considers in the present paper only the phenomena which are seen with a lattice composed of numerous parallel openings. The one employed by him had 1440 parallel lines upon a plane glass $54^{mm.}$ by $13^{mm.}$ The spectrum obtained by this lattice could be projected upon a trough filled with a fluorescent liquid, upon paper impregnated with such a liquid, upon a ruler of uranium-glass or upon photographic paper. The spectrum as projected upon a common paper screen exhibited between the two spectra of the first order toward the centre and between the two lines H in the violet, an ill defined dark space. When fluorescent paper was made to receive the spectrum, this dark space became at once sharply defined. The spectrum was longer upon chinin-paper than upon the other fluorescent substances which the author tried, and he confined himself to this in his investigation. The author gives a mathematical investigation of the spectrum as produced by parallel openings, and then makes with the compasses upon the fluorescent paper the requisite measurements of the distances of the points where the first bright spectrum of the diffracted light commences. The wave length is then given by the formula $\lambda = e \sin \psi$, in which e represents the distance between two successive lattice-openings and ψ the angle which the diffracted ray makes with the normal to the surface of the lattice. By placing a violet-colored glass over the opening near the heliostat, the most refrangible end of the spectrum became visible with still greater distinctness and exhibited the sharpest termination: even on common paper the spectrum could be seen and with exactly the same length. When the spectrum as thus produced was received upon a plate of porcelain, no trace of extension could be remarked; the spectrum terminated with the extreme visible rays. The author found as the results of his measurements the following wave lengths in fractions of a millimeter.

Extreme visible red rays $\lambda = 0{\cdot}0007064$.
Extreme visible violet rays $\lambda = 0{\cdot}0003956$.
Most refrangible invisible rays $\lambda = 0{\cdot}0003540$.

Hence it appears that light from the extreme red to the extreme invisible ray embraces a complete octave.

With the view of confirming this result the author produced upon chinin-paper a spectrum by means of the same object-glass and a Munich flint glass prism of 45° at a distance of 7 meters. In this manner many of Fraunhofer's and Stokes's lines were seen with great distinctness. The distances of these lines were measured from the line B, and laid off as ordinates upon an axis of abscissas upon which the single distances of the ordinates are expressed by the difference of the corresponding wave lengths. In this manner the author obtained a curve which from the line H to the extreme invisible ray appears to follow the same law as the other portions of the spectrum. Eisenlohr has furthermore found that crown glass does not absorb the invisible rays in such a manner as to shorten the spectrum. This effect is produced by the low dispersive power of the glass for the invisible rays. This is shewn by the fact that a plate of crown glass placed so that the rays constituting the interference spectrum should pass through it before falling upon the chinin-paper does not produce any shortening of the spectrum. By piercing a hole in the screen upon which the spectrum was received where the invisible rays fell the

author separated these and employed them for various experiments on polarization, double refraction and dispersion, which he promises to describe hereafter.—*Pogg. Ann.* xcviii, 353, *June*, 1856.

2. *On the connection between the theorem of the equivalence of heat and work and the relations of permanent gases.*—Clausius has published some critical remarks upon the paper of Hoppe which has been noticed in this Journal,* his object being mainly to shew that he himself had considered the subject from a different point of view and had arrived at essentially the same results as Hoppe. In a memoir "On a change in the form of the second principal theorem of the mechanical theory of heat," Clausius deduced the equation

$$(1) \qquad Q = U + A.W,$$

in which Q denotes the heat communicated to a body during any change of state, W the external work performed, A the equivalent of heat for the unit of work, and U a quantity of which it may be assumed that it is perfectly determined by the initial and terminal state of the body. In the present notice the author deduces the results of Hoppe from this equation in the following simple manner. For the special case in which the state of the body is given by its temperature t and its volume v, U may be considered as a function of these two quantities. When the external work consists only in overcoming a pressure p which opposes the expansion, we have

$$W = \int p\, dv,$$

and we obtain from the previous equation by differentiation,

$$(2) \qquad dQ = \frac{dU}{dt}\, dt + \left(\frac{dM}{dv} + A.p\right) dv.$$

In applying this equation to the more special case of a permanent gas we may express the factors of dt and dv in another manner. The first of these two factors $\frac{dU}{dt}$ is evidently nothing but the specific heat at a constant volume, and we write for it c. To express the second factor, the specific heat at a constant pressure, c' must be introduced. According to the laws of Gay Lussac and Mariotte, we have

$$p.v = \frac{p_0.v_0}{a+t_0}(a+t),$$

in which a represents the inverse volume of the coefficient of expansion. Hence we have

$$dv = \frac{p_0.v_0}{(a+t_0)p}\, dt.$$

Substituting this value for dv we have

$$dQ = \left[\frac{dU}{dt} + \frac{p_0.v_0}{(a+t_0)p}\left(\frac{dU}{dv} + A.p\right)\right] dt.$$

The sum in the parenthesis [ ] represents the quantity c', and if we subtract from it the quantity $c = \frac{dU}{dt}$ we have

* Vol. xxi, p. 409.

$$c'-c=\frac{p_0 \cdot v_0}{(a+t_0)p}\left(\frac{dU}{dv}+A \cdot p\right),$$

and hence for the second factor the expression

$$\frac{dU}{dv}+A \cdot p=\frac{a+t_0}{p_0 \cdot v_0}(c'-c)p.$$

By substituting these expressions in (2), we have

$$(3) \quad dQ=c\,dt+\frac{a+t_0}{p_0 \cdot v_0}(c'-c)p\,dv,$$

or if we signify the integration

$$(4) \quad Q=\int c\,dt+\frac{a+t_0}{p_0 \cdot v_0}\int(c'-c)\,p\,dv,$$

which is the sought equation. It is easy to see also that a deviation from the laws of Mariotte and Gay Lussac can be taken into consideration in this investigation as easily as in that of Hoppe.—*Pogg. Ann.* xcviii, 173, *May*, 1856.

3. *On Ozone.*—Andrews has communicated the results of a very elaborate and extended investigation of this subject, which forms an important contribution to our knowledge. The author in the first place repeated the experiments of Baumert, who arrived at the conclusion that ozone is a peroxyd of hydrogen, having the formula HO_3. Andrews found that no two experiments led to the same constitution for this peroxyd, and finally discovered that the discrepancy was owing to a small quantity of carbonic acid which, without great care, is always mixed with electrolytic ozone. In Baumert's experiments the increase of weight of the apparatus was always greater than the weight of the ozone as deduced from its chemical action. Andrews found, however, that when the carbonic acid was completely removed these two quantities exactly agreed, so that it is proved that water is not a product of the decomposition of ozone, and therefore that this contains no hydrogen. In like manner it was shewn that no water is produced when ozone is decomposed by heat. The ozone obtained by electrolysis by the action of the electric spark and by the oxydation of phosphorus was found to be identical. Finally, it was found that ozone contained no nitrogen. The author concludes from his investigation that ozone is oxygen in an allotropic modification, and not a compound body as supposed by Schönbein, Williamson, and Baumert.—*Phil. Tr. for* 1855, *quoted in Pogg. Ann.* xcviii, 435, *June*, 1856.

4. *Preparation of Aluminum.*—Brunner has prepared aluminum directly from the fluorid instead of employing cryolite. The fluorid is prepared by dissolving alumina in fluohydric acid, or rather by condensing the acid in the alumina. The fluorid is then reduced by sodium in a hessian crucible, a layer of common salt being placed above the mixture. The yield is not stated.—*Pogg. Ann.* xcviii, 488.

5. *On the conversion of carbonic oxyd into formic acid, and on the preparation of formic from oxalic acid.*—Berthelot has found that when carbonic oxyd is heated in contact with hydrate of potash, formate of potash is produced, the reaction being represented by the equation

$$2CO + KO, HO = C_2HO_3, KO.$$

This observation suggested to the author that formic acid might be produced easily and abundantly by making carbonic oxyd unite with water at the instant of its formation. As oxalic acid is decomposed by heating into carbonic acid, carbonic oxyd and water, it occurred to Berthelot that by heating this acid with some substance which should act by contact, the water and carbonic oxyd would unite to produce formic acid. Glycerin was found to answer the purpose perfectly. The author introduces into a retort of 2 litres capacity, 1 kilogram of syrupy glycerin, 1 kilogram of commercial oxalic acid, and 100–200 grammes of water. A receiver is to be attached and the retort heated gently to 100° C.: carbonic acid is given off, and after from twelve to fifteen hours all the oxalic acid is decomposed, while a little weak formic acid has passed over. Half a liter of water is to be added to the matter in the retort and the whole distilled, water being added from time to time to make up the loss, until 6–7 liters of fluid have distilled over. The distillate then contains almost the whole of the formic acid, while pure glycerin remains in the retort, and may be used again and again. From 3 kilograms of oxalic acid the author obtained 1·051 kilograms of formic acid, which is very nearly the theoretical amount. In this very simple and easy process it is only necessary to proceed slowly and not at too high a temperature, since when the mass reaches 190°–200° pure carbonic oxyd is given off. By this process carbonic oxyd may be prepared in a state of purity, the carbonic acid being first given off. The formic acid is pure and free from oxalic acid.—*Comptes Rendus*, xli, 955 *and* xlii, 447.

[*Note.*—Berthelot's process for preparing formic acid is so easy and elegant that this important substance can hereafter be furnished at a low price and in a state of purity. Its numerous and valuable applications in analytical chemistry will probably be speedily recognized; but it would be well worth while to examine its action in the place of acetic acid in photographic processes.—W. G.]

6. *On the determination of chlorine by titrition.*—With the view of rendering the end of the reaction more distinctly visible, MOHR has suggested the addition of a little neutral chromate of potash to the liquid containing the chlorid. The red color of the chromate of silver makes its appearance as soon as the last trace of chlorine is precipitated as chlorid of silver, and the end of the process is thus very distinct. Levol suggested the employment of phosphate of soda with the same object in view, but a much larger quantity of nitrate of silver solution must be added in this case to produce the yellow color, and the end of the reaction is therefore much less definite. In a second paper, Mohr has extended the method to the determination of many other substances by first converting them into chlorids and then determining the chlorine as above. [The method appears to give in many cases satisfactory results, but it is unfortunately inapplicable in the case of colored solutions. It is to be regretted that the ingenious author does not give a greater number of numerical data to prove the accuracy of the method in the various cases to which he applies it. We would also suggest that the practice of comparing the results obtained by a particular analytical method with theory by the difference should be abandoned, and that in all cases the percentage obtained should be stated.—W. G.]—*Ann. der Chemie und Pharmacie*, xcvii, 335, xcix, 197.

7. *Reduction of aluminum from cryolite.*—Wöhler has found it advantageous in the preparation of aluminum to mix the finely pulverized and well dried cryolite with an equal weight of a mixture of 7 parts of chlorid of sodium and 9 of chlorid of potassium previously melted together and then finely pulverized. The mixture is to be introduced into a hessian crucible in alternate layers with slices of sodium, the separate layers being pressed strongly together. For every 50 grammes of the mixture, 8 or 10 grammes of sodium are to be used. The crucible must be previously strongly dried. It is then to be quickly heated to a white heat in a good furnace. At the moment of reduction a noise is heard and some sodium is volatilized which burns with flame. After this the heat must be kept up for a quarter of an hour to fuse the mass completely, and then allowed to cool. On breaking the crucible, the aluminum is found as a single white regulus, usually with a crystalline surface. In this way about 4 per cent of the weight of the cryolite is obtained, which is only about one-third of the aluminum in the mineral. The aluminum is free from silicon.—*Ann. der Ch. und Pharm.* xcix, 255, *Aug.* 1856.

8. *Researches on the Fluorids.*—Fremy has communicated the results of an elaborate investigation of the compounds of fluorine beginning as it were, *de novo*, from the very elements of the subject, and re-examining many points which have long been considered as settled. The author sums up his conclusions in the following words:—

(1.) Fluohydric acid may be obtained from anhydrous acid in a state of purity by calcining, in a platinum apparatus, the fluohydrate of fluorid of potassium, previously dried. In this state the acid is gaseous at ordinary temperatures; it attacks glass and all silicious substances strongly, contrary to the assertions which have been made on this point of late years.

(2.) All the experiments described in this memoir, confirm the views of the constitution of fluohydric acid now received by all chemists, and shew that this acid really behaves like a hydracid.

(3.) It results from the general study of the fluorids which has been made, that these compounds may be divided into three classes, and that to each of these classes belongs an assemblage of important properties. The first class comprises the anhydrous fluorids which are comparable to the chlorids; the second the hydrated fluorids which behave, in all their reactions, like fluohydrates; in the third class we find the fluohydrates of fluorids which are true acid salts.

(4.) The anhydrous fluorids are remarkable for their stability; the hydrated fluorids are, on the contrary, unstable, and sometimes decompose even when they are dried in vacuo, disengaging fluohydric acid and leaving as a residue an oxyfluorid or oxyd.

(4.) The fluorids have a great tendency to unite to form double fluorids; this property belongs even to the insoluble fluorids. Thus these last compounds must never be prepared by double decomposition, because they always retain, in their state of double salt, a part of the soluble salt which has been employed in their preparation.

(6.) Hydrogen does not decompose all the fluorids by the aid of heat; thus it does not act on the fluorids of calcium: but it reduces with the greatest facility, the fluorids of lead, tin, &c. The reduction of the metallic fluorids by hydrogen, like those of lead and tin, which resist the action

of carbon, appears to demonstrate, in a positive manner that these compounds do not contain oxygen, and are really binary substances.

(7.) All fluorids, even those of potassium, sodium and calcium, are rapidly decomposed by the vapor of water.

(8.) Oxygen and chlorine, at a strong heat, decompose fluorid of calcium, and set free a gas which appears to be fluorine.

(9.) The vapor of sulphur does not act on fluorid of calcium, but this body is decomposed completely by the vapor of sulphid of carbon; there is formed in this case sulphid of calcium, and probably fluorid of carbon; the presence of silicious matters facilitates the reaction.

(10.) The analyses of the principal fluorids which are cited in this memoir, as those of the fluorids of potassium, sodium, calcium, tin, lead and silver, show that the equivalent of fluorine, determined by Berzelius, is exact.

(11.) All the anhydrous fluorids, when fused, may be decomposed by the galvanic battery, and disengage a gas which appears to be the radical of the fluorids.—*Ann. de Chimie et de Physique*, xlvii, 5, *May*, 1856.

9. *On two new methods of producing Urea artificially.*—Natanson has succeeded in showing that carbamid and urea are identical. When carbonate of ethyl and ammonia are heated together in a sealed tube to 100° C., only urethan is formed; but at 180°, the urethan is converted, by the excess of ammonia into urea. When phosgene gas and ammonia are brought into contact, a white saline mass is formed, first studied in 1838, by Regnault, and which behaves like a mixture of carbamid and sal-ammoniac. Regnault did not succeed in separating the two substances or in proving that urea was present. This Natanson has done, and it is therefore proved that urea and carbamid are identical.

10. *On Acetylamin.*—Natanson has more fully described this very interesting alkaloid, which he obtains by distilling the hydrated oxyd of acetyl-ammonium, which at a high temperature is decomposed into acetylamin and water, according to the equation

$$\left.\begin{matrix} C_4H_3 \\ H \\ H \\ H \end{matrix}\right\} NO, HO = \left.\begin{matrix} C_4H_3 \\ H \\ H \end{matrix}\right\} + 2HO.$$

The decomposition begins at 150° C.; the acetylamin distils over at 220°, as a slightly yellow liquid of peculiar ammoniacal persistent smell. It boils at 218°, and is soluble in all proportions in water and alcohol, but not in ether. The density of its vapor was found to be 1·522=4 vols. By union with acids it forms salts of acetyl-ammonium, from which it is very remarkable that potash precipitates the hydrate of the oxyd of acetyl-ammonium and not acetylamin. The author describes an ethyl acetylamin and an anilin acetylamin—*Ann. der Chemie und Pharmacie*, xcviii, 287, 291, *June*, 1856.

W. G.

11. *The Manufacture of Malleable Iron and Steel without Fuel*, (Proc. Brit. Assoc., August, 1856; Ath. No. 1504.)—At a meeting of the British Association for the Advancement of Science, held at Cheltenham in August last, Mr. H. Bessemer read a highly interesting and important paper on the manufacture of malleable iron and steel without fuel. For two years

Mr. Bessemer has devoted his attention almost exclusively to the subject. Preliminary trials were made on from ten to twenty pounds of iron, and "although the process was fraught with considerable difficulty, it exhibited such unmistakeable signs of success," Mr. Bessemer observed, "as to induce me at once to put up an apparatus, capable of converting about seven hundred of crude pig iron into malleable iron in thirty minutes."

"I set out with the assumption that crude iron contains about five per cent. of carbon; that carbon cannot exist at a white heat in the presence of oxygen without uniting therewith and producing combustion; that such combustion would proceed with a rapidity dependent on the amount of surface of carbon exposed: and, lastly, that the temperature which the metal would acquire would be also dependent on the rapidity with which the oxygen and carbon were made to combine, and consequently that it was only necessary to bring the oxygen and carbon together in such a manner that a vast surface should be exposed to their mutual action, in order to produce a temperature hitherto unattainable in our largest furnaces.

With a view of testing practically this theory, I constructed a cylindrical vessel of three feet in diameter and five feet in height, somewhat like an ordinary cupola furnace, the interior of which is lined with fire bricks; and at about two inches from the bottom of it I insert five tuyère pipes, the nozzles of which are formed of well-burned fire clay, the orifice of each tuyère being about three-eights of an inch in diameter; they are so put into the brick lining (from the outer side) as to admit of their removal and renewal in a few minutes when they are worn out. At one side of the vessel, about half way up from the bottom, there is a hole made for running in the crude metal, and on the opposite side there is a tap-hole stopped with loam, by means of which the iron is run out at the end of the process. In practice this converting vessel may be made of any convenient size, but I prefer that it should not hold less than one, or more than five tons, of fluid iron at each charge. The vessel should be placed so near to the discharge hole of the blast furnace as to allow the iron to flow along a gutter into it; a small blast cylinder will be required capable of compressing air to about 8lb. or 10lb. to the square inch.

A communication having been made between it and the tuyères before named, the converting vessel will be in a condition to commence work; it will, however, on the occasion of its first being used after relining with fire-bricks, be necessary to make a fire in the interior with a few baskets of coke, so as to dry the brickwork, and heat up the vessel for the first operation, after which the fire is to be all carefully raked out at the tapping-hole, which is again to be made good with loam. The vessel will then be in readiness to commence work, and may be so continued, without any use of fuel, until the brick lining in the course of time, becomes worn away, and a new lining is required. I have before mentioned that the tuyères are situated nearly close to the bottom of the vessel; the fluid metal will therefore rise some eighteen inches or two feet above them.

It is therefore necessary, in order to prevent the metal from entering the tuyère holes, to turn on the blast before allowing the fluid crude iron to run into the vessel from the blast furnace. This having been done, and the fluid iron run in, a rapid boiling up of the metal will be heard

going on within the vessel, the metal being tossed violently about and dashed from side to side, shaking the vessel by the force with which it moves, from the throat of the converting vessel. Flame will then immediately issue, accompanied by a few bright sparks. This state of things will continue for about fifteen or twenty minutes, during which time the oxygen in the atmospheric air combines with the carbon contained in the iron, producing carbonic acid gas, and at the same time evolving a powerful heat.

Now, as this heat is generated in the interior of, and is diffusive in innumerable fiery bubbles through the whole fluid mass, the metal absorbs the greater part of it, and its temperature becomes immensely increased, and by the expiration of the fifteen or twenty minutes before-named, that part of the carbon which appears mechanically mixed and diffused through the crude iron has been entirely consumed. The temperature, however, is so high that the chemically combined carbon now begins to separate from the metal, as is at once indicated by an immense increase in the volume of flame rushing out of the throat of the vessel. The metal in the vessel now rises several inches above its natural level, and a light frothy slag makes its appearance, and is thrown out in large foam-like masses. This violent eruption of cinder generally lasts about five or six minutes, all further appearance of it ceases, when a steady and powerful flame replaces the shower of sparks and cinder which always accompanies the boil.

The rapid union of carbon and oxygen which thus takes place adds still further to the temperature of the metal, while the diminished quantity of carbon present allows a part of the oxygen to combine with the iron, which undergoes combustion and is converted into an oxyd. At the excessive temperature that the metal has now acquired, the oxyd as soon as formed undergoes fusion, and forms a powerful solvent of those earthy bases that are associated with the iron. The violent ebullition which is going on mixes most intimately the scoria and the metal, every part of which is thus brought in contact with the fluid oxyd, which will thus wash and cleanse the metal most thoroughly from the silica and other earthy bases which are combined with crude iron, while the sulphur and other volatile matters which cling so tenaciously to iron at ordinary temperatures, are driven off, the sulphur combining with the oxygen and forming sulphurous acid gas.

The loss in weight of crude iron, during its conversion into an ingot of malleable iron, was found on a mean of four experiments to be 12½ per cent, to which will have to be added the loss of metal in the finishing rolls. This will make the entire loss probably not less than 18 per cent, instead of about 28 per cent., which is the loss on the present system. A large portion of this metal, however, is recoverable by treating with carbonaceous gases the rich oxyd thrown out of the furnace during the boil. These slags are found to contain innumerable small grains of metallic iron, which are mechanically held in suspension in the slags, and may be easily recovered. I have before mentioned that after the boil has taken place a steady and powerful flame succeeds, which continues without any change for about ten minutes, when it rapidly falls off.

As soon as this diminution of flame is apparent, the workman well know that the process is completed, and that the crude iron has been

converted into pure malleable iron, which he will form into ingots of any suitable size and shape by simply opening the tap-hole of the converting vessel and allowing the fluid malleable iron to flow into the iron ingot-moulds placed there to receive it. The masses of iron thus formed will be perfectly free from any admixture of cinder, oxyd or other extraneous matters, and will be far more pure, and in a forwarder state of manufacture than a pile formed by ordinary puddle bars. And thus it will be seen that by a single process, requiring no manipulation or particular skill, and with only one workman, from three to five tons of crude iron passes into the condition of several piles of malleable iron in from thirty to thirty-five minutes, with the expenditure of about one-third part the blast now used in a finery furnace with an equal charge of iron, and with the consumption of no other fuel than is contained in the crude iron.

To those who are best acquainted with the nature of fluid iron it may be a matter of surprise that a blast of cold air forced into melted crude iron is capable of raising its temperature to such a degree as to retain it in a perfect state of fluidity after it has lost all its carbon, and is in the condition of malleable iron, which in the highest heat of our forges only becomes softened into a pasty mass. But such is the excessive temperature that I am enabled to arrive at with a properly shaped converting vessel and a judicious distribution of the blast, that I am able not only to retain the fluidity of the metal, but to create so much surplus heat as to re-melt the crop ends, ingot runners, and other scrap that is made throughout the process, and thus bring them without the labor or fuel into ingots of a quality equal to the rest of the charge of new metal. For this purpose a small arched chamber is formed immediately over the throat of the converting vessel, somewhat like the tunnel-head of the blast furnace. This chamber has two or more openings on the sides of it, and its floor is made to slope downwards to the throat.

As soon as a charge of fluid malleable iron has been drawn off from the connecting vessel, the workman will take the scrap intended to be worked into the next charge and proceed to introduce the several pieces into the small chamber, piling them up around the opening of the throat. When this is done he will run in his charge of crude metal, and again commence the process. By the time the boil commences the bar ends or other scrap will have acquired a white heat, and by the time it is over most of them will have been melted and run down into the charge. Any pieces, however, that remain, may then be pushed in by the workman, and by the time the process is completed they will all be melted, and ultimately combined with the rest of the charge, so that all scrap-iron, whether cast or malleable, may thus be used up without any loss or expense.

As an example of the power that iron has of generating heat in this process, I may mention a circumstance that occurred to me during my experiments: I was trying how small a set of tuyères could be used, but the size chosen proved to be too small, and after blowing into the metal for one hour and three-quarters I could not get up heat enough with them to bring on the boil. The experiment was therefore discontinued, during which time two-thirds of the metal solidified, and the rest was run off. A larger set of tuyère pipes were then put in, and a fresh charge of fluid

iron run into the vessel, which had the effect of entirely remelting the former charge, and when the whole was tapped out, it exhibited, as usual, that intense and dazzling brightness peculiar to the electric light.

To persons conversant with the manufacture of iron it will be at once apparent that the ingots of malleable metal which I have described will have no hard or steely parts, such as is found in puddled iron, requiring a great amount of rolling to bend them with the general mass, nor will such ingots require an excess of rolling to expel cinder from the interior of the mass, since none can exist in the ingot, which is pure and perfectly homogeneous throughout, and hence requires only as much rolling as is necessary for the development of fibre; it therefore follows that, instead of forming a merchant bar or rail by the union of a number of separate pieces welded together, it will be far more simple and less expensive to make several bars or rails from a single ingot; doubtless this would have been done long ago had not the whole process been limited by the size of the ball which the puddler could make.

The facility which the new process affords of making large masses will enable the manufacturer to produce bars that on the old mode of working it was impossible to obtain; while, at the same time, it admits of the use of some powerful machinery whereby a great deal of labor will be saved, and the process be greatly expedited. I merely mention this fact in passing, as it is not my intention at the present moment to enter upon any details of the improvements I have made in this department of the manufacture, because the patents which I have obtained for them are not yet specified.

Before, however, dismissing this branch of the subject, I wish to call the attention of the meeting to some of the peculiarities which distinguish cast-steel from all other forms of iron, namely, the perfect homogeneous character of the metal, the entire absence of sand-cracks or flaws, and its greater cohesive force and elasticity as compared with the blister-steel from which it is made, qualities which it derives solely from its fusion and formation into ingots, all of which qualities malleable iron acquires in like manner by its fusion and formation into ingots in the new process. Nor must it be forgotten that no amount of rolling will give to blister-steel (although formed of rolled bars) the same homogeneous character that cast-steel acquires by a mere extension of the ingot to some ten or twelve times its original length.

One of the most important facts connected with the new system of manufacturing malleable iron is that all the iron so produced will be of that quality known as charcoal iron, not that any charcoal is used in its manufacture, but because the whole of the processes following the smelting of it are conducted entirely without contact with, or the use of any mineral fuel; the iron resulting therefrom will, in consequence, be perfectly free from those injurious properties which that description of fuel never fails to impart to iron that is brought under its influence. At the same time, this system of manufacturing malleable iron, offers extraordinary facility for making large shafts, cranks, and other heavy masses; it will be obvious that any weight of metal that can be founded in ordinary cast-iron by the means at present at our disposal may also be founded in molten malleable iron, and be wrought into the forms and

shapes required, provided that we increase the size and power of our machinery to the extent necessary to deal with such large masses of metal. A few minutes' reflection will show the great anomaly presented by the scale on which the consecutive processes of iron-making are at present carried on. The little furnaces originally used for smelting ore have from time to time increased in size, until they have assumed colossal proportions, and are made to operate on 200 or 300 tons of materials at a time, giving out ten tons of fluid metal at a single run. The manufacturer has thus gone on increasing the size of his smelting furnaces, and adapting to their use the blast apparatus of the requisite proportions, and has by this means lessened the cost of production in every way; his large furnaces require a great deal less labor to produce a given weight of iron than would have been required to produce it with a dozen furnaces, and in like manner he diminishes his cost of fuel-blast and repairs, while he insures a uniformity in the result that never could have been arrived at by the use of a multiplicity of small furnaces. While the manufacturer has shown himself fully alive to these advantages, he has still been under the necessity of leaving the succeeding operations to be carried out on a scale wholly at variance with the principles he has found so advantageous in the smelting department. It is true that hitherto no better method was known than the puddling process, in which from 400 to 500 weight of iron is all that can be operated upon at a time, and even this small quantity is divided into homœopathic doses of some seventy or eighty pounds, each of which is moulded and fashioned by human labor, carefully watched and tended in the furnace, and removed therefrom one at a time, to be carefully manipulated and squeezed into form.

When we consider the vast extent of the manufacture, and the gigantic scale on which the early stages of the process are conducted, it is astonishing that no effort should have been made to raise the after-processes somewhat nearer to a level commensurate with the preceding ones, and thus rescue the trade from the trammels which have so long surrounded it.

Before concluding these remarks I beg to call your attention to an important fact connected with the new process, which affords peculiar facilities for the manufacture of cast-steel.

At that stage of the process immediately following the boil, the whole of the crude iron has passed into the condition of cast-steel of ordinary quality; by the continuation of the process the steel so produced gradually loses its small remaining portion of carbon, and passes successively from hard to soft steel, and from soft steel to steely iron, and eventually to very soft iron; hence, at a certain period of the process, any quality of metal may be obtained; there is one in particular which, by way of distinction, I call semi-steel, being in hardness about mid-way between ordinary cast-steel and soft malleable iron. This metal possesses the advantage of much greater tensile strength than soft iron; it is also more elastic, and does not readily take a permanent set, while it is much harder, and is not worn or indented so easily as soft iron; at the same time it is not so brittle or hard to work as ordinary cast-steel. These qualities render it eminently well adapted to purposes where lightness and strength are specially required, or where there is much wear, as in the case of

railway bars, which from their softness and lamellar texture soon become destroyed. The cost of semi-steel will be a fraction less than iron, because the loss of metal that takes place by oxydation in the converting vessel is about $2\frac{1}{2}$ per cent. less than it is with iron; but, it is a little more difficult to roll, its cost per ton may fairly be considered to be the same as iron; but, as its tensile strength is some thirty or forty per cent. greater than bar-iron, it follows that for most purposes a much less weight of metal may be used, so that, taken in that way, the semi-steel will form a much cheaper metal than any that we are at present acquainted with.

In conclusion, allow me to observe that the facts which I have had the honor of bringing before the meeting have not been elicited from mere laboratory experiments, but have been the result of working on a scale nearly twice as great as is pursued in our largest iron works, the experimental apparatus doing seven cwt. in thirty minutes, while the ordinary puddling furnace makes only $4\frac{1}{2}$ cwt. in two hours, which is made into six separate balls, while the ingots or blooms are smooth even prisms, ten inches square by thirty inches in length, weighing about equal to ten ordinary puddle balls."

12. *On some Dichromatic Phenomena among Solutions, and the means of representing them;* by Dr. GLADSTONE, (Proc. Brit. Assoc. August, 1856; Ath. No. 1505.)—This paper was an extension of Sir John Herschel's observations on dichromatism, that property whereby certain bodies appear of a different color according to the quantity seen through. It depends generally on the less rapid absorption of the red ray as it penetrates a substance. A dichromatic solution was examined by placing it in a wedge-shaped glass-trough, held in such a position that a slit in the window-shutter was seen traversing the varying thicknesses of the liquid. The diversely colored line of light thus produced was analyzed by a prism; and the resulting spectrum was represented in a diagram by means of colored chalks on black paper, the true position of the apparent colors being determined by the fixed lines of the spectrum. In this way the citrate and comenamate of iron, sulphate of indigo, litmus in various conditions, cochineal, and chromium, and cobalt salts were examined and represented. Among the more notable results were the following:—A base, such as chromic oxyd, produces very nearly the same spectral image with whatever acid it may be combined, although the salts may appear very different in color to the unaided eye. Citrate of iron appears green, brown, or red, according to the quantity seen through. It transmits the red ray most easily, then the orange, then the green, which covers the space usually occupied by the yellow; it cut off entirely the more refrangible half of the spectrum. Neutral litmus appears blue or red, according to the strength or depth of the solution. Alkalies cause a great development of the blue ray; acids cause a like increase of the orange, while the minimum of luminosity is altered to a position much nearer the blue. Boracic acid causes a development of the violet. Alkaline litmus was exhibited so strong that it appeared red, and slightly acid litmus so dilute that it looked bluish purple; indeed, on account of the easy transmissibility of the orange ray through an acid solution, the apparent paradox was maintained that a large amount of alkaline litmus is of a purer red than acid litmus itself. Another kind of dichromatism was examined,

dependent not on the actual quantity of colored material, but on the relative proportion of the solvent. Diagrams of the changing appearances of sulphocyanid of iron, of chlorid of copper, and of chlorid of cobalt were exhibited.

13. *On several new Methods of detecting Strychnia and Brucia;* Experiments on Animals with Strychnia, and probable reasons for non-detection of Strychnia in certain cases; and a new method of instituting post-mortem researches in Strychnia; by Mr. T. Horsley, (Proc. Brit. Assoc., Aug. 1856; Ath. No. 1503.)—In the first lecture, Mr. Horsley observed that the circumstances attending Palmer's trial induced him to make a series of experiments on the subject, and he tried the effects of a precipitant formed of one part of bichromate of potash dissolved in fourteen parts of water to which was afterwards added two parts in bulk of strong sulphuric acid. This being tried upon a solution of strychnine, the bulk was entirely precipitated in the form of a beautiful golden-colored and insoluble chromate. The experiment, as performed by Mr. Horsley, was very interesting, and scarcely a trace of bitterness was left in the filtered liquor. He did not claim to have originated this discovery of the use of a chromic salt and an acid liquor; but the point to which he called attention was the essential difference in the mode of application, and he maintained that it was as much out of the power of any human being to define the limit of sensibility which he had attained, as it would be to count the sands or to measure the drops of the ocean. Taking thirty drops of a solution of strychnia containing half a grain, he diluted it with four drams of water. He then dropped in six drops of a solution of bichromate of potash, when crystals immediately formed, and decomposition was complete. Splitting up the half grain of strychnia into millions of atoms of minute crystals, he said that each of these atoms, if they could be separated, would as effectually demonstrate the chemical characteristics of strychnia as though he had operated with a pound weight of the same. He then showed the chemical reaction with those crystals. Dropping a drop of liquor containing the chromate of strychnia into an evaporating dish and shaking it together, he added a drop or two of strong sulphuric acid, and showed the effect as previously noted. He next showed the discoloration produced in chromate of strychnia and chromate of brucia by sulphuric acid, the former being changed to a deep purple and then to a violet and red. It had been asserted since the trial of Palmer that the non-detection of strychnine in the body of John Parsons Cook was owing to the antimony taken by the deceased having somewhat interfered with the tests. Such a supposition was, in his (Mr. Horsley's) opinion, absurd. Nothing, he considered, could more incontestably disprove the fallacy than either of two new tests which he then performed. These he considered double tests, because they had first the obtainment of a peculiar crystalline compound of strychnine, which was afterwards made to develop the characteristic effects by which strychnine is recognized. Mr. Horsley next related a series of experiments which he had made on animals with strychnine, and entered into the probable reasons for its non-detection in certain cases, although (as he had just shown before) a method of detecting infinitesimal quantities of strychnia by tests. Having procured three rats at seven o'clock P. M., he (assisted by Dr.

Wright) gave each rat a quarter of a grain of powdered strychnia, and two hours afterwards a quarter and half a grain more to one of the three. Next morning at four o'clock they were all alive, and had eaten food (bread and milk) in the night, but at seven, or a few minutes after, they were all dead. The longest liver was one of the rats that had had only a quarter of a grain. In about three hours afterwards he applied the usual test, but could not detect the least indication of strychnine in the precipitate. There was, moreover, a total absence of bitterness in all the liquor. He tried every part of the bodies of the rats with the like results. What, then, became of the strychnine? Had it been decomposed in the organism, and its nature changed, as Baron Liebig intimated? As to the non-detection of strychnine, he thought it not improbable that the strychnine might have become imbibed into the albumen or other solid matter, and so abstracted from the fluid, forming by coagulation (say, for instance, in the blood) a more or less insoluble albuminate. This idea had occurred to him from noticing the coagulation of the glairy white of egg with strychnine, and the fact of his not recovering the full quantity of the alkaloid whenever he had introduced it. At any rate, it merited consideration. In his second experiment he administered three-quarters of a grain of strychnia to a wild rat, but the animal evinced little of the effects of the poison, and it was purposely killed after five days. His third experiment was with two grains of strychnia, administered as a pill wrapped up in blotting-paper, to a dog—a full-sized terrier. It was apparently quite well for five hours, when the operator went to bed, but was found dead next morning, but lying apparently in the most natural position for a dog asleep. When taken up blood flowed freely from its mouth. On opening the animal (continued Mr. Horsley) I found the right ventricle of the heart empty of blood, whilst the left was full, some of the blood being liquid and some clotted. The stomach was carefully secured at both its orifices, and detached. On making an incision, I was surprised at not seeing the paper in which I had wrapped the pill, naturally expecting it would have been reduced to a pulp by the fluid of the stomach. I, therefore, sought for it, and lo! here it is, in precisely the same condition as when introduced into the gullet of the dog, and containing nearly all the strychnine. I have been afraid to disturb it until I had exhibited it to you, and now I will weigh the contents, and ascertain how much has been absorbed or dissolved. This experiment is important as showing the small quantity of strychnia necessary to destroy life; and, had I not been thus particular to search for the paper envelope, it might, possibly, have led to a fallacy, as I must have used an acid, and that would have dissolved out the strychnia, and the inference would have been that it was obtained from the contents of the stomach, whereas it had never been diffused. In this case, also, none of the absorbed strychnia was detectable in the blood or any part of the animal, although the greatest care was observed in making the experiments. The lecturer, who was listened to throughout with great attention, added that he had made further experiments, which he thought proved that it was highly probable a more or less insoluble compound of organic or animal matter with strychnia is found.

II. GEOLOGY.

1. *On the Spongeous Origin of the Siliceous Bodies of the Chalk Formation;* by J. S. Bowerbank, (Proc. Brit. Assoc., August, 1856; Ath. No. 1505.)—The author attributes the whole of the numerous strata of nodular and tabular flints to vast quantities of spongeous bodies that existed in the seas of those remote periods. The elective attraction of the animal matter of the sponges inducing the deposit of the silex, which in the first instance is always in the form of a thin film surrounding the skeleton of the sponge, and from which successive crops of calcedonic crystals proceed, until the solidification of the whole is effected. The tabular form is accounted for on the presumption that the sponges originating the deposit grew on a more consolidated bottom than the tuberous ones, and that they therefore developed themselves in a lateral direction instead of in an erect position, and on approximating each other were cemented together, and thus formed continuous beds of considerable extent; and the author illustrated this portion of his subject by the production of four recent sponges of the same species, which, by being placed in contact while in the living state, became firmly united to each other within eighteen hours, ultimately forming one sponge. The occurrence of the shells of Echinoderms and of bivalve shells filled with flint was accounted for on the same principle; and the author produced recent bivalve shells, in a closed condition, completely filled with recent sponges of the same species as the sponges of commerce. The loose specimens of fossil sponges included in the Wiltshire flints were explained on the principle that, although sponges of the same species readily adhere to each other when placed in contact, those of different species never unite, however closely they may be pressed together. The author concluded his paper by applying the same principles to the siliceous deposits of the whole of the geological formations which were of aqueous origin.

2. *On some Palæozoic Starfishes, compared with Living Forms;* by J. W. Salter, (Proc. Brit. Assoc., August, 1856; Ath. No. 1505.)—The object of the communication was chiefly to exhibit some new forms of Asteriadæ, from the Upper Silurian rocks, which have all the aspect of Ophiuridæ, but are essentially distinguished by the number of ossicles which go to form a single segment of the arms,—the lower surface showing the characteristic double row of ambulacral bones (in this case flat plates,) and the upper being composed either of two or more rows of plates, while the Ophiuridæ have a single plate above, and one below. There is, however, the closest similarity to the latter family in the length of the arms and the restriction of the disc (*Protaster*, Forbes), as well as in the great length of the spines on the margin (*Palæocoma*), while in the pentagonal form and simply plated integument of another genus (*Palasterina*), there is a much nearer approach made to the Asteriscus or *Palmipes roseus* than to any other type of living starfish. It is to this group that the fossils are supposed to belong; and to some of the species which have the disc little developed, or quite absent, there is a strong resemblance in a Lower Silurian form originally described by Forbes as *Uraster*, but which better specimens show to have had but two rows of suckers, and the avenues bordered by very large plates. The name Pa-

læaster is proposed for this group, which is represented by four or five species. The genera are;—*Palæaster* (Salter), without disc, avenues deep, Upper and Lower Silurian, 4 species; *Palasterina* (ib.), pentagonal, disc moderate, Up. Sil., 1 species; *Palæocoma* (ib.), no disc, avenues very shallow, Up. Sil., 4 species; *Protaster* (Forbes), disc small, arms long, extended, Upper (and Lower) Sil., 4 species. There appear to be no other forms yet described.

3. *On the Physical Structure of the Earth;* by Prof. Hennessy, (Proc. Brit. Assoc.; Ath. No. 1504.)—After some preliminary observations as to the impossibility of accounting for the earth's figure, without supposing it to have been once a fused mass, the exterior of which has cooled into a solid crust, the process of solidification of the fluid was described. The influence of the connexion and circulation of the particles in a heterogeneous fluid was shown to be different from what would take place in a homogeneous fluid such as usually come under our notice. As the primitive fluid mass of the earth would consist of strata increasing in density from the surface towards the centre, its refrigeration would be that of a heterogeneous fluid, and the process of circulation would be less energetic in going from its surface towards its centre. Thus, the earth would ultimately consist of a fluid nucleus inclosed in a spheroidal shell. The increase in thickness of this shell would take place by the solidification of each of the surface strata of the nucleus in succession. If the matter composing the interior of the earth is subjected to the same physical laws as the material of the solid crust coming under our notice, the change of state in the fluid must be accompanied by a diminution of its volume. The contrary hypothesis has been hitherto always assumed in mathematical investigations relative to the form and structure of the earth. The erroneous supposition that the particles of the primitive fluid retained the same positions after the mass had advanced in the process of solidification as they had before the process commenced, had been tacitly or openly assumed in all such inquiries until it was formally rejected by the author, who proposed to assume for the fluid similar properties to those exhibited by the fusion and solidification of such portions of the solidified crust as are accessible to observation. The results to which the improved hypothesis has led show that it fundamentally affects the whole question, not only of the shape and internal structure of the earth, but also of the various actions and reactions taking place between the fluid nucleus and the solid shell. If the process of solidification took place without change of volume in the congelation of the fluid, the strata of the shell would possess the same forms as those of the primitive fluid, and their oblateness would diminish in going from the outer to the inner surface. If the fluid contracts in volume on passing to the solid state, the remaining fluid will tend to assume a more and more oblate figure after the formation of each stratum of the shell. The law of density of the nucleus will not be the same as that of the primitive fluid, but will vary more slowly, and the mass will thus tend towards a state of homogeneity as the radius of the nucleus diminishes by the gradual thickening of the shell. The surface of the nucleus, and consequently the inner surface of the shell, will thus tend to become more oblate after each successive stratum added to the shell by congelation from the nucleus.

This result, combined with another obtained by Mr. Hopkins, proves that so great pressure and friction exist at the surface of contact of the shell and nucleus as to cause both to rotate together nearly as one solid mass. Other grounds for believing in the existence of the great pressure exercised by the nucleus at the surface of the shell were adduced. If the density of the fluid strata were due to the pressures they support, and if the earth solidified without any change of state in the solidifying fluid, the pressure against the inner surface of the shell would be that due to the density of the surface stratum of the nucleus, and would, therefore, rapidly increase with the thickness of the shell. Contraction in volume of the fluid on entering the solid state would diminish this pressure, but yet it may continue to be very considerable, as the co-efficient of contraction would always approach towards unity. The phenomena of the solidification of lava and of volcanic bombs were referred to in illustration of these views, and their application was then shown to some of the greatest questions of geology. The relations of symmetry which the researches of M. Elie de Beaumont seem to establish between the great lines of elevation which traverse the surface of the earth appear to Prof. Hennessy far more simply and satisfactorily explained by the expansive tendency of the nucleus which produces the great pressure against the shell than by the collapse and subsidences of the latter. The direction of the forces which would tend to produce a rupture from the purely elevatory action of the pressure referred to would be far more favorable to symmetry than if the shell were undergoing a distortion of shape from collapsing inwards. The nearly spherical shape of the shell would also greatly increase its resistance to forces acting perpendicularly to its surface, so as to cause it to subside, while the action of elevatory forces would not be resisted in the same manner.

4. *On the Great Pterygotus* (*Seraphim*) *of Scotland, and other Species;* by Mr. J. W. SALTER, (Proc. Brit. Assoc., August, 1856; Ath. No. 1504.) This paper was in some measure a continuation of one published in the *Quarterly Geological Journal* for 1855, describing some new and large Crustacean forms from the uppermost Silurian rocks of the south of Scotland. They were described under the name of Himanthopterus, and were supposed to differ from the published fragments of the great Pterygotus by the lateral position of the large simple eyes. In the general shape of the body, however, the terminal joints and tail, in the want of appendages to the abdomen, as well as in the form and number of the swimming feet, mandibles, maxillæ and antennæ, there was found to be on further examination the closest resemblance between Himanthopterus and the great Pterygotus. And the resemblance has been carried still further by the favorable collocation of all the known specimens from the Scotch collections which have furnished us with nearly all the portions, and also with the head, which we now find to be exactly like that of Himanthopterus, having *lateral*, not *subcentral*, eyes, as represented by other authors. The two genera are therefore identical, and the group, as now constituted, includes a number both of small and moderate-sized crustacea, along with some which were far larger than any living species, and which certainly attained a length of six or eight feet! The collections made by the Scotch geologists, in connection with other specimens

obtained by Mr. Banks, of Kington, and Messrs. Lightbody & Cockis, of Ludlow, show us that Pterygotus was an elongate crustacean, with a comparatively small head and sessile compound eyes, few appendages, of which the large chelate antennæ are most remarkable, being a foot long and only four-jointed,—the terminal joints forming a strong serrated claw. The large mandibles were fully six inches long; the maxillæ, either one or two pairs, with six-jointed palpi; and the great swimming feet consisting of six joints, of which the terminal ones were modified as for swimming, and the basal joints are great foliaceous expansions, which possibly assisted, like the joints of the legs in Limulus, in mastication. From the explanations given by Mr. Huxley in the memoir above referred to, there is a general resemblance both in form and structure to the small Stomapod crustaceans, Mysis and Cuma, two minute forms, which must be arranged very low down in the scale of Decapod crustaceans, and which are also frequently ornamented with a simular sculpture to that of the fossils. There is even a yet greater resemblance in form to the larvæ of the common crab. And if this be accepted, the coincidence in essential structure between such minute and embryonic forms and these gigantic denizens of the old seas becomes most remarkable and interesting, as bearing on the course of development of life throughout geological epochs.

5. *On the Bone Beds of the Upper Ludlow Rock, and the base of the Old Red Sandstone;* by Sir R. I. Murchison, (Proc. Brit. Assoc., August, 1856; Ath. No. 1504.)—Sir Roderic Murchison gave an account of the recent and additional discoveries made in those strata, which, whether they pertain to the uppermost beds of the Silurian rocks, or to the lowest junction strata of the Old Red Sandstone, have been grouped under the term of "Tilestones." In his original description of the uppermost Ludlow rock he had described a certain layer, near their summit, as being characterized by the remains of bones of fishes, principally the defences of Onchus, with jaws and teeth, and numerous coprolitic bodies. But he had also noticed, in several localities, the occurrence of a still higher bed, which seemed to form a passage into the Old Red Sandstone, and in which remains of terrestrial plants occurred. He had further pointed out, that the upper Ludlow rock was the lowest stratum in which the remains of Vertebrata were discovered,—an observation which has remained uncontroverted till the present day, no remains of true fishes having yet been detected in more ancient strata in any part of Europe. In an ascending order, however, it was well known that Ichthyolites augmented rapidly; and the object of the present communication is to show how the recent observations of Mr. Richard Banks, of Kington, and of Mr. Lightbody, of Ludlow, have made us acquainted with the presence of fish remains in two thin courses *above* the original bone-bed of the upper Ludlow rock. The lower of these beds, which, according to the sections exhibited, occurs both at Kington and at Ludlow, was recently inspected by himself, accompanied by Prof. Ramsay and Mr. Aveline, as well as by Mr. Salter. It is a greyish or yellowish flag-like sandstone, the lowest course of which at Kington contains many spines of Onchus, with *Lingula cornea.* This thin layer, and another softer one full of remains of Pterygotus and two species of Pteraspis, are surmounted by the blue or grey-hearted building-stone of Kington, with Pterygotus,

Lingula cornea, &c. These again are covered by less massive beds, which contain fragments of plants and large Pterygoti, and which graduate upwards insensibly into more micaceous sandstones, often splitting into tiles. The *Lingula cornea* and *Trochus helicites* together with species of Modiolopsis and a small Beyrichia, all generally considered characteristic of the uppermost Ludlow rock, prevail throughout these strata, with occasional carbonaceous matter and traces of land vegetation; clearly indicating an upward passage towards the younger formation of Old Red Sandstone. The last-mentioned (or middle) fish bed is probably the same as that which Sir R. I. Murchison described in the Silurian System as occurring in Clun Forest and other places. It has recently been laid open by the cutting of the railroad northeast of the town of Ludlow, and exhibits similar relations,—a grey rock beneath passing into an overlying micaceous sandstone. The same succession is obscurely traceable on the right bank of the Ferne, below Ludford. This bed is also characterized by the presence of vegetable remains, seed vessels, jaws and spines of Onchus, with fragments of crustaceans (Pterygotus and Eurypterus), in short, just the same assemblage as that which occurs at Bradnor Hill, near Kington, and has been described by Mr. Banks. Again, on the right bank of the Tane, the next strata in ascending order which are visible, and which have lately been accessible owing to the dry weather, consist of micaceous brownish red sandstone and red marls, with true cornstone concretions, exposed in the bed of the river, which are again followed by other marls and sandstones, surmounted by a band of coarse, greenish, micaceous sandstone, in which are found remains both of fishes and of Pterygotus. The fish remains consist of distinct jaws and teeth of considerable size, of fin defences (Onchus), and the heads of *Cephalaspis Lyellii*, and a new species; together with these, the *Lingula cornea* occurs. The genus Pterygotus having now been found through the upper Silurian rocks, and even so low down as the upper Caradoc formation, can no longer be considered characteristic of the transition beds between the Silurian and Devonian rocks; and as the genera Cephalaspis and Pteraspis are now known to extend their range into true upper Ludlow strata, our views regarding the precise zoological characters, which separate the two formations, must be modified accordingly. As regards the English frontier of the Silurian rocks, the phenomena present no ambiguity; for all the strata, from the *lowest* bone-bed of the true Ludlow rock, which contains so many species of shells of Silurian age, to the *uppermost* fish-bed, which must be included in the Old Red Sandstone, do not exceed forty or fifty feet in thickness,—the upper part of the series constituting a true mineral and zoological passage into the Old Red Sandstone. In conclusion, the author observed, that the lithological term "*tilestones*," if applied either to the top of the upper Ludlow rock or to the base of the Old Red Sandstone exclusively, might mislead; but if applied generally to the beds of transition between the two deposits, it may still be a convenient and applicable term.

6. *On a Fossil Mammal* (*Stereognathus ooliticus*) *from the Stonesfield Slate;* by Prof. Owen, (Proc. Brit. Assoc., Aug., 1856; Ath., No. 1503)—Prof. Owen exhibited, by favor of the Rev. J. P. B. Dennis, M. A., a portion of a lower jaw, with three molar teeth, of a small mammal,

from the oolitic slate of Stonesfield, Oxfordshire, for which the name of *Stereognathus ooliticus* had been proposed; and after a minute description of the characters of the bone and teeth, he entered upon the question of its probable affinities. These could only be judged of by the peculiarities of certain molar teeth of the lower jaw of the unique fossil. Those teeth presented the singular complexity of six cusps or cones upon the grinding surface, in three longitudinal pairs, the crown of the tooth being quadrate, broadest transversely, but very short *or low*. The jawbone presents a corresponding shallowness and thickness. The cusps are sub-compressed: the outermost and innermost of the three hinder ones are oblique, and converge towards the middle of the crown, being overlapped by the outermost and innermost of the three front cones. The three molar teeth occupy the extent of $4\frac{1}{2}$ lines, or 1 centimeter; each tooth being 3 millimeters in fore and aft extent, and nearly 4 millimeters in transverse extent. After a comparison of these molars with the multicuspic teeth of the rat, the hedgehog, the shrews and Galeopitheci, the author showed that the proportions, numbers and arrangement of the cusps in those Insectivora forbad a reference of the Stereognathus, on dental grounds, to that order. The same negative result followed a comparison of the fossil with the sex-cuspid teeth of the young Manatee. The author finally proceeded to point out closer resemblances to the sex-cuspid teeth of the mammals of the eocene, Hyracothere, Microthere and Hyopotamus; but in these the resemblance was presented only by the teeth of the upper jaw. The lower molar teeth of the Chœropotamus, to which the author deemed those of the Hyracotherium would most closely approximate when discovered, showed a rudiment of the intermediate cones between the normal pairs of cones. The proportional size and regularity of the cones of the grinding teeth of the Stereognathus, give quite a different character of the crown from that of the multicuspid molars of the Insectivora, and cause the sex-cuspid crown of the oolitic mammal to resemble the pente-cuspid and quadri-cuspid molars of the before-cited extinct Artiodactyle genera. Prof. Owen concluded, therefore, that the Stereognathus was most probably a diminutive form of non-ruminant Artiodactyle, of omniverous habits.

7. *On the Dichodon cuspidatus, from the Upper Eocene of the Isle of Wight and Hordwell, Hants;* by Prof. Owen, (Proc. Brit. Assoc., Aug. 1856; Ath., No. 1503.)—Prof. Owen communicated the results of examinations of additional specimens of jaws and teeth of the *Dichodon cuspidatus*, which he had received since his original Memoirs on that extinct animal in the Quarterly Journal of the Geological Society, vol. iv., (June, 1847). The first specimen described supplied the characters of the last true molar tooth of the lower jaw, which had not been previously known. This tooth has six lobes, the additional posterior pair being less than the normal ones, and more simple. The inner surface of the inner lobe has an accessary cusp at the back part of its base, but not at the fore part as in the other lobes. The length of the last lower molar was nine lines, that of the first and second molars being each six lines. A specimen of the *Dichodon cuspidatus* from the Hordwell Sands, in the British Museum, supplied the characters of the permanent incisors, canine, and three anterior premolars of the upper jaw: all these teeth closely corres-

pond in form with the corresponding deciduous teeth, but are of larger size. Finally, a portion of the lower jaw of an aged specimen of Dichodon, in the British Museum, showing the effects of attrition on the last molar tooth, was described, and the results of this additional evidence confirmed the conclusions of the author as to the generic distinction of the Dichodon.

8. *On a Range of Volcanic Islets to the Southeast of Japan;* by Mr. A. G. FINDLAY, (Proc. Brit. Assoc., August, 1856; Ath., No. 1503.)—The recent importance of our commercial relations with Japan, consequent upon the opening of the ports of Nagasaki and Hakodadi to our merchants, and the increasing commerce now developing itself between Eastern Asia and Northwest America, has rendered the great ocean-highway between Nippon and the Bonin Islands of great interest. The dangers of this region to the seaman are much increased by the rapid Japanese current, first shown by the author in 1850 to run from east to west across the North Pacific Ocean, in an analogous course to the Atlantic Gulf Stream. This mighty stream running to the ENE, through the space under consideration, has given rise to the very complicated nature of the so-believed new discoveries. Above thirty of these announcements being, by investigation, reduced to five or six rocky islets of very singular character. The islands nearest to Japan, the Broken Ids. Falsisyo, the Japanese penal colony, and South Island, were shown to be in some cases defectively represented. The Redfield Rocks are those discovered by Broughton, and corrected by Capt. Donnell in 1850, and therefore not a discovery by the United States Japan Expedition in 1854. The islands south of this are, perhaps, Tibbit Island of 1844, then an island or reef of pointed rocks, discovered by Coffin in 1825, afterwards announced as new by Captain Jurien-Lagravière in May, 1850; again announced as new by Captain Rogers in 1851; again in 1852 by Captain Dresher of the Walter, and again in 1856 by Capt. Grove, each person believing that he had discovered a new island. Others similar were also cited. The next group, perhaps, is about eight miles to the south of the last, or lat. 31° 53′ N., long. 139° 59′ E., was discovered in the Dutch corvette, the Koerier, August 24, 1849, and are of a very dangerous character. Jeannette Island, twenty-three miles further south, is doubtful. Smith Island, in lat. 31° 12′, long. 139° 55′, discovered by Capt. Smith of the Heber, March, 1846, is a most singular needle-rock, springing from unfathomable depths to 300 feet high and not more than 250 feet diameter at the base. It has been seen by others. Ponafidin Island of the Russians lies next, to the south. St. Peter's or Black Rock, first seen in 1821, and again in 1853, is a wonderful column of basalt or volcanic glass, 200 feet high, parallel and quite perpendicular sides, not more than 150 feet in diameter, and like a bottle in appearance. It is in lat. 29° 42′, long. 140° 15′. The volcanic nature of these remarkable rocks lying near the meridian of 140° E. indicates a continuation of those immense volcanic ranges which pass along the Kurile Islands, throughout Nippon, the great Japanese island, and thence to the well-known range of spiracles in the Ladrone Islands. At the northern end of this range is the well-known Mount Fusi, 10,000 or 12,000 feet in height, now quiescent. To the south of this volcano is Simoda,—a port between the two capitals of Ja-

pan, Jeddo and Miako, which has been thrown open to the commerce of the United States in 1854. The dreadful earthquake of 1854 at this place was alluded to. It totally changed the character of the harbor of Simoda, destroyed the fine city of Osaca, and injured Jeddo. The wave which was caused by this upheaval of the land traversed the entire breadth of the North Pacific in twelve hours and some few minutes, a distance of between 4,000 and 5,000 miles, demonstrating the depth of that ocean to be between two and three miles. The diagram illustrating the paper showed the singular confusion before mentioned in the hydrography of these small but important positions. The Bonin Islands lie to the southward. They have recently been made the subject of some uncourteous disputation by the Americans as to the right of discovery and ownership. There can be no doubt of their Japanese discovery, and are the Arzbispo Islands of the early Spaniards. Next follows Captain Coffin in 1824–5, who was believed to be an Englishman, but which is controverted by Commodore Perry of the U. S. N. The particulars of the discovery were related. Next, Captain (now Admiral) Beechy saw them in 1827, and took possession of them before the discovery of Coffin was published. They were colonized under the direction of H. B. M.'s consul at Oahu in 1830, the survivors of those settlers still living there. These islands have been lately explored by the United States Japan Expedition, and their volcanic origin established. It was hoped that some authority to repel aggression would be established there, as the islands have now become valuable as a coaling and refitting station for steam-vessels. The Volcano Isles which follow are tolerably well-known, and from these the volcanic submarine ridges diverge to SSE, and SW, several isolated shoals and volcanic rocks having been discovered in these directions. The paper concluded with a hope that our naval officers would endeavor to clear up the embarrassing confusion which had arisen from the imperfect accounts given of this now important region.

9. *On the New Red Sandstone Formation of Pennsylvania ;* by Isaac Lea, (Proc. Acad. Nat. Sci. Phil., April, 1856.)—Mr. Lea read some notes from a paper he is preparing for the Journal of the Academy on the Red Sandstone Formation of Pennsylvania, and stated that he had, during an excursion last summer, found in the dark shales of that Formation, near Phœnixville, on the Schuylkill, the tooth of a Sauroid Reptile which he thus characterised.

Centemodon* sulcatus. Tooth smooth, rather thick, slightly curved, with trenchant edges, rounded on the exterior portion, sulcate on the lower part near the base, covered with very minute, distinct striæ from the point to the base, which striæ cross the sulcations in slightly oblique lines. Length sixteen-twentieths of an inch; greatest breadth four-twentieths of an inch; pulp cavity large.

On comparing this tooth with *Clepsysaurus Pennsylvanicus*, which he had described from the same Red Sandstone Formation in Lehigh county, it is found to differ very widely. The edge is not serrate on any part as in that genus, nor is it so large or so attenuate. The form, too, is more compressed. It differs in size from the teeth of *Bathygnathus borealis* of Leidy, from the New Red Sandstone of Nova Scotia, being smaller and more attenuate, as well as in having a trenchant smooth edge and not a

* Κέντημα aculeus and ὀδούς dens.

serrate edge. It is about the size and approaches the form of Prof. Owen's figure of *Labyrinthodon*, Plate 63 A. f. 2, of his Odontographia, but it is more flattened.

Mr. Lea also stated that in the greenish and blackish shales of the same locality he found two species of *Posidonia*, which genus is so characteristic of this portion of the formation and existing in immense quantities. As they seem to differ from that figured by Sir Charles Lyell, in his Elementary Geology, as coming from the Oolitic coal shale of Richmond, Virginia, Mr. Lea proposed the names of *P. ovata* and *P. parva*, the first being about seven-twentieths of an inch in transverse diameter. The latter is more rotund, and about three-twentieths of an inch in transverse diameter, both being covered with numerous minute concentric costæ over the whole disc.

Near to this locality and superimposed, Mr. Lea obtained a specimen of impure dull red limestone, which contained, on a partially decomposed surface, impressions presenting the appearance of *Foot-marks*, somewhat like *Chelichnus Duncani*, Owen, figured by Sir Wm. Jardine in his Ichnology, for which Mr. Lea proposed the provisional name of *Chelichnus Wymanianus*, after Professor Wyman, of Cambridge, Mass.

From the same formation and locality were procured the impressions of plants, some of which belong to the *Coniferæ*. One of the cones was nearly six inches long and full an inch wide. These were accompanied by other plants of very obscure character, covering large portions of the surface of some of the layers. Mr. Lea also mentioned that he had observed the same Red, Black and Gray Shales at Gwynedd, on the North Pennsylvania Railroad, where he found the same *Posidoniæ*, and some of the same obscure plants, impressions of which covered the surfaces of many of the rocks. A single specimen was obtained of a plant with long leaves somewhat resembling *Noeggerathia cuneifolia*, Brongniart, which is from the Permian.

In the Black Posidonia Shales was found a single Ganoid scale, which is more like *Pygopteris mandibularis*, Agas., from the Marl Slate (Lower Permian) than any other which had come under Mr. Lea's notice. There were other obscure forms observed, which have not yet been satisfactorily found to be analogous to any known forms, but which Mr. Lea hoped to be able to make out when he should figure all the specimens and describe them more at large for the Journal of the Academy.

10. *Descriptions of New Species of Acephala and Gasteropoda, from the Tertiary formations of Nebraska Territory, with some general remarks on the Geology of the country about the sources of the Missouri River;* by F. B. Meek and F. V. Hayden, M. D., (Proc. Acad. Nat. Sci., Philad., viii, 101.)—That portion of the great Tertiary basin from which the fossils described in the following paper were obtained, occupies an extensive area of country near the head waters of the Missouri, chiefly between the 46th and 49th parallels of north latitude, and the 100th, and 108th degree of longitude west from Greenwich. According to the barometrical measurements made by the party charged with the exploration of the proposed northern route of the Pacific railroad, this district varies in its elevation from 1800 to 2700 feet above the present flow of the tidal wave.*

* Some points not crossed by these explorers may be a few hundred feet higher.

In regard to the geographical, topographical, and physical features of this country, its native tribes, its botany, zoology, &c., much interesting information was long since laid before the public by the Reports of Lewis and Clark's and Long's expeditions, by Mr. Catlin, the Prince of New-Wied, Mr. Nuttall and others. More recently, much information of a similar nature has been added by the report of the Pacific Railroad Survey. All these enterprising travellers mention the occurrence of sandstones, clays, lignite, &c., but without giving us much information in regard to the age of these formations, the extent of country occupied by them, or the character of their organic remains.

In 1849, Dr. John Evans traced a great Lignite formation from below Fort Clark, along the Missouri, to a point twenty miles below the mouth of the Yellow-Stone; and in 1850 Mr. Thaddeus A. Culbertson, who visited this country under the patronage of the Smithsonian Institution, saw this formation at two or three points above Fort Union. In a map accompanying a highly interesting memoir on the geology of the Hudson's Bay Territories, published recently by Mr. A. K. Isbister, in the Journal of the Geological Society of London, a large area about the sources of the Missouri, is colored as Tertiary, but so as to convey an incorrect idea of the extent of country occupied by it. About the same time, Mr. Jules Marcou published in the Bulletin of the Geological Society of France, a memoir on the Geology of the United States and the British Provinces, accompanied by a map, on which he colors nearly all the country about the head waters of the Missouri as New Red Sandstone, surmounted along the west shore of that stream by Cretaceous outliers. Between this and the Black Hills he brings up to Cannon-ball River, from the White River basin, a continuous belt of Tertiary. West of this he places a belt of Jurassic, and along the supposed position of the Black Hills he runs a stripe of eruptive and metamorphic rocks, flanked on the east and west by Carboniferous formations. On the west side of the Black Hills he colors another extensive district of Jurassic. In all this Mr. Marcou is certainly mistaken, excepting in regard to the eruptive and metamorphic rocks of the Black Hills; there may also be Carboniferous formations there, but they have not yet been recognized as far north by two or three hundred miles, as laid down by him.

Leaving for a future occasion all local and other details, we now propose to give a brief general sketch of the extent and boundaries, as far as we can, of that portion of the great Tertiary lignite formation from which our fossils were collected, with a few remarks upon its probable age, and relations to the White River basin, as well as to the Cretaceous formations upon which it reposes.

Ascending the Missouri from Fort Pierre, we find on reaching a point five miles below Heart River, about the 47th parallel north, that the Cretaceous formations which are so conspicuous for many hundred miles along the river below, pass by a gentle north or north-west dip beneath the water level, to be succeeded on both sides of the river by tertiary. Although this is the first point where the tertiary beds come down to the water level, they are known to occupy the higher country back from the river, on the west side, as far south as the vicinity of *Sawacanna* or Moreau river, and still farther west they go as far south as some of the north-

west branches of the Cheyenne. Cannon-ball river, Watahoo, and other small tributaries, however, cut down to the Cretaceous beds some little distance back from the Missouri. On the east side of the Missouri the Tertiary is bounded on the south, nearly opposite the mouth of Cannon-ball river, by a range of Upper Cretaceous hills bearing off to the northeast. South of the Moreau, a similar range, known as Fox Hills, extends from near the Missouri to about 102° of west longitude, where it is interrupted by a small tributary of the Cheyenne. West of this small stream, the same range of Upper Cretaceous hills, known perhaps by other local names, bears round to the northwest, crossing the head branches of the Little Missouri so as to strike the Yellow-Stone river about ten miles below the mouth of Powder river; forming nearly all this distance the south and southwest boundaries of that portion of the great Tertiary basin lying in the immense bend formed by the Missouri and Yellow-Stone rivers. To comprehend how this range of hills could traverse the country in this way, it must be borne in mind that the Black Hills are laid down on most of the published maps of this country as extending a long distance too far north.

Returning to the point near Heart river, from which we first set out, we find on ascending the Missouri, that the Cretaceous strata again rise to view at a few points not far below Fort Clark, but even here the country on each side is composed of Tertiary. It was at one of these localities the Prince of New Wied collected a nearly entire skeleton of *Mosasaurus Maximiliani* (Goldf.). From the vicinity of Fort Clark we know of no other place where the Cretaceous beds make their appearance until about twelve miles below the mouth of Milk river, (lat. 47° N., long. 104° W.,) the country on both sides of the Missouri all this great distance being made up of Tertiary formations, the northern and eastern limits of which are unknown to us. Immediately along the margins of Milk river, Cretaceous beds are seen on both sides as far up as we have any knowledge of the country, though the higher country back from the river is Tertiary. From the point below the mouth of this stream on the Missouri, where the Cretaceous beds first make their appearance, they are seen to rise higher and higher as we ascend the Missouri, in consequence of their inclination to the east or northeast. On the north side of the Missouri, between it and Milk river, the higher portions of the country back from the Missouri, are also composed of Tertiary beds.

The same formations likewise occupy nearly all the country between the Missouri and the Yellow-Stone, as far west as the vicinity of Muscleshell river, where they thin out on the summits of Cretaceous hills. The hills, however, near the Missouri, between Milk and Muscleshell rivers, are also mainly Cretaceous, the Tertiary being for the most part worn away by atmospheric agencies.

On both sides of the Yellow-Stone, only Tertiary strata are seen from near the mouth of Powder river as far up as the mouth of the Big Horn. How far beyond this they extend we do not know, though we have received Tertiary fossils from intelligent traders, collected as far up the Big Horn as one of its tributaries known as Little Horn river. From another point as far west on the Yellow-Stone as Rose river, we received a few Cretaceous fossils. As to the limits of the Tertiary up Powder and

Tongue rivers, we have no definite information. The traders say the same kind of lignite beds seen along the Yellow-Stone, occur along the banks of the former as much as one hundred and fifty miles above its mouth.

The foregoing hasty sketch is given more with a view of showing the extent of the country occupied by this great Tertiary lignite formation, than with any hope of conveying a definite idea of its precise limits. If it should prove to be only a part of the same extensive fresh water lignite formation observed by Sir John Richardson on the Saskatchawan, of which we have little doubt, then it is highly probable the lignite and coal formations mentioned by Mr. Isbister as flanking the eastern slope of the Rocky Mountains, in the form of a continuous belt from the Saskatchawan to the Arctic Ocean, belong to the same epoch.

For the most part, these deposits in Nebraska consist of beds of gray, yellowish, whitish, and blue sand, sandstone, clay, &c., with alternating strata and clay. These beds of lignite often take fire spontaneously, from heat generated in the decomposition of iron pyrites, and burn for many years at a time, sending forth suffocating sulphurous vapors, and causing such an intense degree of heat as to fuse the contiguous clay and sand into masses presenting every degree of compactness, from that of obsidian to light vesicular lava. In some of the argillaceous beds, great numbers of beautiful fossil plants are found, a fine series of which was collected and placed for investigation in the hands of Dr. J. S. Newberry, the well known botanical palæontologist of Cleveland, Ohio. The remains of Mollusca collected from these formations, over a wide extent of country, present a remarkable uniformity of character, and as may be seen by the following paper, are all, excepting a few land shells, referable to genera usually found in fresh and brackish waters. It is an interesting fact that the most nearly allied living representatives of many of these species are now found inhabiting the streams of South Africa, Asia, China, and Siam, apparently indicating the existence of a tropical climate in these latitudes at as late a period as the Tertiary epoch.*

Although there can be no doubt that these deposits hold a rather low position in the Tertiary System, we have as yet been able to arrive at no very definite conclusions as to their exact synchronism with any particular minor subdivision of Tertiary, not having been able to identify any of the Mollusca found in them with those of any well marked geological horizon in other counties. Their general resemblance to the fossils of the Woolwich and Reading series of English geologists, as well as to those of the great Lignite formations of the southeast of France, would seem to point to the lower Eocene as their position. Yet it may be possible these resemblances have resulted from the action of precisely similar causes at a somewhat later period.

It is a little remarkable that these formations differ in many respects from those of the White River basin lying so near on the south. In the first place they generally contain more sand, are usually characterized by beds of lignite, and as yet have furnished no remains of Mammalia;

* We are under many obligations to Dr. Issac Lea, of Philadelphia, for the privilege of comparing our fossil species with analogous forms in his magnificent collection of recent shells.

while the White River basin is more argillaceous, appears to be destitute of lignite, and is well known to be one of the most remarkable repositories of extinct mammalian remains on the face of the globe. In addition to this, not one of the species of Mollusca in our collection from the Lignite formations, is identical with any of those described by Dr. Evans and Dr. Shumard from the White River basin.

Formations immediately beneath the Tertiary in this district.—It would seem that the change of physical conditions which closed the Cretaceous epoch and ushered in the Tertiary, in this part of the world at least, was gradual, not violent. We find that even while the Cretaceous conditions still existed, (during the deposition of No. 5 of the series*) the approaching close of that state of things, and the coming of the Tertiary era, were foreshadowed by the introduction of *Fasciolaria*, *Pleurotoma*, and *Belemnitella*, with many shells of other genera, quite as near in their specific affinities to Tertiary as to Cretaceous forms; while the sea was gradually becoming more shallow, as is shown by the increase of *Gasteropoda*. We even know from the presence of a few remains of *Lycopodiaceous* plants, and an occasional unbroken leaf of some *Exogenous* tree, that there was dry land at this time somewhere not very far away. Gradually, as we ascend in the series, the strictly marine animals disappear, and we meet with *Ostrea*, *Corbula*, and *Cerithium*, mingled in the same bed with *Melania*, *Paludina*, *Physa*, *Cyrena*, &c., all of tertiary types; while a little higher in the series we find at some places only the remains of land and fresh-water Mollusca.

From the above facts, especially the presence of *Pleurotoma*, *Fasciolaria*, and *Belemnitella*, in this upper member of the Cretaceous system of this country, we cannot think it represents any part of the Green Sand of English geologists. Numerous well marked Cretaceous forms show it cannot be Tertiary, consequently we think it must represent some portion of the true chalk. We are by no means inclined, however, to adopt the views of M. Alcide D'Orbigny, who regards all the Cretaceous formations of the United States and Western Territories as referable to a later epoch than the Green Sand, as the next succeeding formation below that of which we have just been speaking, (No. 4 of the series), is characterized by numerous fossils of unquestionable Green Sand type. We think confusion has been created in tracing out the parallelism between American and European Cretaceous formations, by fossils from different positions in this country having been mingled together and described as if they occurred in the same bed.

Formations at the base of the Cretaceous Series of this district.—As previously stated, near the mouth of Milk river, Cretaceous strata which are not seen for a long distance below this on the Missouri, again rise to view. They consist of the upper two members of the series (No. 5 and No. 4) which, in consequence of their inclination to the east, are found to rise higher and higher as we ascend the river, so that nearly all the hills close to the Missouri, between Milk and Muscleshell rivers, consist of these formations. Some four or five miles below the mouth of Muscleshell

* For a section of the rocks of this country, see a paper by James Hall and F. B. Meek in the Memoirs Am. Acad. Arts and Sci., vol. 5, New Series. Likewise a paper by F. B. Meek and F. V. Hayden in Proceed. Acad. Nat. Sci. Philad, March, 1856.

river, a lower rock, a sandstone, rises above the water level. This is probably No. 1 of the series, No. 2 and No. 3 not being represented here. It is worthy of note that out of two species of *Mactra*, two of *Tellina*, two of *Inoceramus*, one of *Pholadomya*, two of *Natica*, and one *Baculite*, found in this rock, not one is known to occur in any of the higher formations, and some of these species are not unlike *Neocomian* forms.

In consequence of the increasing inclination of the strata, this last mentioned sandstone rises in the vicinity of North Mountain river as much as 250 feet above the Missouri. Here, or near this, begins a wild and desolate region, known as the *Mauvaises Terres* or Bad Lands of the Judith. At various places in these Bad Lands a sandstone similar to No. 1 was seen alternating with beds of clay and lignite, all of which are upheaved and much distorted. It was found impossible to devote to the examination of these formations time enough to determine their relations to the Cretaceous and Tertiary strata of this region, without running the risk of being cut off from the party and murdered by the Indians. Amongst a few fossils that were collected here, however, Prof. Leidy finds teeth which he refers to two or three genera of large *Saurians* allied to the *Iguanodon*, *Megalosaurus*, &c. There are also in the collection from some of these beds, one or two species of *Unio*, one or more of *Cyclas* or *Cyrena*, and a few crushed specimens of *Gasteropoda* like *Paludina* and *Melania*. From these facts, we are strongly inclined to think with Prof. Leidy, that there may be here, at the base of the Cretaceous system, a fresh-water formation like the Wealden. Inasmuch, however, as there certainly are some outliers of fresh-water Tertiary in these Bad Lands, we would suggest that it is barely possible these remains may belong to that epoch, though the shells appear to be all distinct species from those found in the Tertiary at all the other localities in this region.

We remember seeing in 1853, between the mouth of Big Sioux and Platte rivers on the Missouri, some exposures very similar to those of the Bad Lands of the Judith, excepting that there appeared to be no beds of Lignite. We saw no fossils in these beds, but were at that time impressed with the opinion that they belonged to the lower part of No. 1, which is well exposed a little higher up the river at the mouth of the Big Sioux, but soon dips beneath the water level to be seen no more between there and the far distant point already mentioned, near the mouth of Muscleshell river.*

[Here follow descriptions of species: *From Fort Union*, Paludina Leai; —*From three miles above Fort Union*, Cyclas formosa, C. fragilis, C. subellipticus, Pupa helicoides, Physa longiuscula, P. rhomboidea.—*Three miles below Fort Union*, Bulimus? teres, B.? vermiculus, Limnæa tenuicosta, Physa Nebrascensis, Planorbis umbilicatus, Velletia (Ancylus) minuta, Paludina retusa, Valvata parvula, Melania minutula.—*Ten miles below Fort Union*, Paludina trochiformis, P. Leidyi.—*Ten miles above Fort Union*, Melania multistriata, M. Nebrascensis.—*Near Moreau river*, with bones of Titanotherium? Cyrena Moreauensis, C. intermedia.—*Bad Lands of the Judith*, Cyrena occidentalis, Physa subelongata, Paludina vetula, P. Conradi, Melania convexa.—*Mouth of the Judith*, associated

* The foregoing remarks are based upon the observations and collections of Dr. Hayden.

with *Ostræa subtrigonalis* Evans and Shumard, also *Melania*, *Paludina*, and other fresh-water shells, Corbula subtrigonalis, C. perundata.—*Fort Clark*, Corbula mactriformis (associated with *Melania*, *Paludina*, etc.,) Bulimus Limneiformis, B. Nebrascensis, Paludina multilineata, P. peculiaris.—*Little Horn River*, Planorbis convolutus.—*Yellow-Stone River, 30 miles above the mouth*, Melania Anthonyi.—*Near headwaters of Little Missouri*, Cerithium Nebrascencis.]

III. BOTANY AND ZOOLOGY.

1. *Alph. DeCandolle: Géographie Botanique raisonnée, ou Exposition des Faites principaux et des Lois concernant la Distribution Géographique des Plantes de l'Epoque Actuelle.* Paris and Geneva, 2 vols., 8vo, 1855.—Pressing engagements have prevented the fulfilment of our promise to make a detailed examination of this work. We exceedingly regret this; for the *Géographie Botanique* of DeCandolle is not only one of the most important works of our day, but one which addresses and will greatly interest, a much broader circle of scientific readers than any other modern production of a botanical author. It is, and probably long will be, the standard treatise upon a wide class of questions, highly and almost equally interesting to the botanist, the zoologist, the geologist, the ethnologist, and the student of general terrestrial physics. To its production the author has devoted no small portion of the best years of his life; and it bears throughout the marks of untiring labor, directed by a remarkably sound, conscientious, and thoroughly systematic mind. Along with the admirable methodical spirit which is his by rightful inheritance, the younger DeCandolle brings to these investigations a particular aptitude for numerical and exact forms, an intimate acquaintance with general physical science, and considerable ethnological and philological learning; which last is turned to good account in his chapters on the history of cultivated and naturalized plants. The result in the work before us,—even if there were no other claims to the distinction,—may fairly be said to go far towards inscribing the name of DeCandolle anew in that select list of philosophical naturalists in which his father holds so eminent a position.

To give some idea of the topics considered in these volumes, and of the order of investigation (which proceeds in an admirable course, from the more simple, general, and better known facts and principles towards the more complex, hypothetical and obscure), we will copy the titles of the chapters, twenty-seven in number; which are arranged in four books, and subdivided into articles, and these again into sections, to such an extent as to fill eight closely printed pages with the bare enumeration. Indeed, this repeated subdivision gives a rigid and rather tedious aspect to some parts of the work, and involves occasional repetitions; but it would not be easy to collocate well and clearly so vast an amount of materials in any better way.

The first Book is occupied with some preliminary considerations upon the way in which temperature, light, and moisture act upon plants. Its three chapters treat of the relations of plants to surrounding physical conditions, and especially to heat and light; and contain the author's

happy distinction between the temperatures actually operative in vegetation, and those which (being below the freezing point, &c.) are altogether null for vegetation, and ought to be eliminated from the tables of mean temperature, when these are viewed in relation to the Northern and Southern geographical range of species.

In Book 2, Geographical Botany, or the study of species, genera, and families, from a geographical point of view; Chap. 4 relates to the limitation of species upon plains and upon mountains, and the probable causes of their actual limits, applied both to spontaneous and cultivated plants; and there is a good endeavor to show that the Northern limit of species is fixed rather by the sum of heat available for vegetation during the growing season, than by the mean temperature of the year. Chap. 5 treats of the shape of the area occupied by a species, a very curions point; and it seems that the area of species inclines to be circular or elliptical. Chap. 6 treats of the association or disjunction of the individuals of a species in its area. Chap. 7 treats of the area of species as to extent of surface, considered as to the families they belong to, as to stations, as to size and duration of the plant, and as to the character of the fruit and seed, whether affording facilities to dispersion or not. Chap. 8 considers the changes which may have taken place in the habitation of species, and discusses with great fullness the whole subject of naturalization, the obstacles in the way, the causes and means of transport, and the interchanges which have been effected between the New and the Old Worlds. Chap. 9 is a very long and interesting one, on the geographical origin of the principal cultivated plants, not only those intentionally, but also those *unintentionally cultivated* by man,—a chapter full of valuable matter, carefully collected and well discussed.* Chap. 10 treats of disjoined species,—those occupying two or more widely separated areas, and not in intermediate stations. Chap. 11 discourses of the early condition and probable origin of the existing species; and brings out the various facts which go far to prove the *geological antiquity of the greater part of existing species*; and that their creation was probably successive. Chap. 12 treats of genera, and their geographical distribution, and maintains the view, (in which we by no means coincide) that genera are truly naturally-limited groups, even more so than species. Chap. 13 is devoted to the distribution of the species of a genus within its area. Chap. 14 treats of the extent of surface occupied by genera. Chap. 15 discourses of the origin and duration of genera. Chap. 16–19 treat of families, as to their area, geographical limits, the distribution of species within the area of the family, &c.

The Third Book is devoted to Geographical Botany, or the characters of different countries considered as to their vegetation. Chap. 20, of the characters of the vegetation of a country; considered, in Chap. 21, as to the relative numbers in the great classes respectively. Chap. 22, com-

* It is singular that M. De Candolle should be so slow to abandon the idea that the aborigines of Carolina, or any other part of North America cultivated or knew anything of the Potato, which, if Raleigh obtained them in Carolina, were certainly imported thither. But, though our aborigines had no *potatoes*, they had *pumpkins* or *squashes* and *beans*, which all writers upon the history of cultivated plants have overlooked, except the late Dr. Harris.

parison of different countries in respect to those natural orders which abound most in species; and Chap. 23, as regards their most characteristic natural families. Chap. 24, on the variety of vegetable forms in different countries and in the world at large, *i. e.*, the probable number of species; the proportion of genera to species, and of orders to genera and species. Chap. 25, the division of the earth's surface into natural botanical regions. Chap. 26, sketch of the vegetation of different countries in respect to the probable origin of their existing species, &c.

The Fourth Book, of a single brief chapter, consists merely of a summary of the author's general conclusions. We give these entire, for convenience availing ourselves of a translation in Hooker's Journal of Botany.*

"The plants now inhabiting the globe have survived many changes, geological, geographical, and, latterly, historical. The history of their distribution is hence intimately connected with that of the whole vegetable kingdom.

To explain existing facts, it is fortunately unnecessary to adopt any conclusion upon the most obscure hypotheses of Cosmogony and Palæontology, or on the mode of creation of species, the number originally created, and their primitive distribution. Botanical Geography can indicate certain probabilities, certain theories, but the principal facts in distribution depend upon more recent and less obscure causes. It suffices to understand and to allow certain facts and theories, which appear probable, namely, that groups of organized beings under different hereditary forms (Classes, Orders, Genera, Species, and Races), have appeared at different places and at different times; the more simple perhaps first, the more complicated afterwards; that each of these groups has had a primitive centre of creation of greater or less extent; that they have, during the period of their existence, been able to become more rare or common, to spread more or less widely, according to the nature of the plants composing them, the means of propagation and diffusion they are possessed of, the absence or presence of animals noxious to them, the form and extent of the area they inhabit, the nature of the successive climates of each country, and the means of transport that the relative positions of land and sea may afford; that many of these groups had become extinct, whilst others have increased, at least as far as can be judged from comparing existing epochs with preceding ones; and lastly, that the latest geological epoch the Quaternary, (that which preceded the existence of man in Europe, and which followed the latest elevation of the Alps), has lasted many thousand years, during which important geographical and physical changes have affected Europe and some neighboring countries, whilst other regions of the globe have suffered no change, or have been exposed to a different series of changes.

"Thus the principal facts of Geology and Palæontology, reduced to the most general and incontestible, suffice to explain the facts of Botanical Geography, or at least to indicate the nature of the explanation, which it requires the progress of many sciences to complete.

* We take this occasion to commend to our readers the detailed notice of De Candolle's work, given last spring, and summer, in a series of the numbers of Hooker's Journal. It comprises a careful abstract of these volumes, and a critical commentary upon many points, abounding in acute and original remarks.

"The most numerous, the most important, and often the most anomalous facts in the existing distribution of plants, are explained by the operation of causes anterior to those now in operation, or by the joint operation of these and of still more ancient causes, sometimes of such as are primitive (connected with the earliest condition of the planet). The geographical and physical operations of our own epoch play but a secondary part. I have shown that in starting from an original fact, which it is impossible to understand, of the creation of a certain form, in a certain country, and at a certain time, we ought to be able, and sometimes are able, to explain the following facts, chiefly by causes that operated previous to our own epoch:—1, the very unequal areas occupied by Natural Orders, Genera, and Species; 2, the disconnection of the areas that some of the species inhabit; 3, the distribution of the species of a genus or family in the area occupied by the genus or family; 4, the differences between the vegetations of countries that have analogous climates and that are not far apart, and the resemblance between the vegetation of countries that are apart, but between which an interchange of plants is now impossible.

"The only phenomena explicable by existing circumstances, are—1, the limitation of species, and consequently of genera and families, in every country where they now appear; 2, the distribution of the individuals of a species in the country it inhabits; 3, the geographical origin and extension of cultivated species; 4, the naturalization of species and the opposite phenomenon of their increasing rarity; 5, the disappearance of species contemporaneous with man.

"In all this we observe proofs of the greater influence of primitive causes, and of those anterior to our epoch; but the growing activity of man is daily effacing these, and it is no small advantage of our progressing civilization that it enables us to collect a multitude of facts of which our successors will have no visible and tangible proof."

An Appendix, indicating the researches now needed for the advancement of Geographical-Botanical science, under several heads, addressed respectively to physicists and meteorologists, to geographers, to geologists, to vegetable physiologists, descriptive and travelling botanists, and to philologists, brings these most interesting volumes to a conclusion.

Our present object is to call the attention of American naturalists and natural philosophers to this work, not to criticise it. That would require much consideration and a wider range of knowledge than we can pretend to. There are, however, several topics upon which we are inclined to venture a few remarks, as fitting opportunities occur. A. G.

2. *Origin of the Embryo in Plants.—Die Befruchtung der Phanerogamien*, Leipsic, 4to, 1856, is the title of a new and important memoir by a young investigator, Dr. Radlkofer, of Munich; whose name bids fair to be celebrated for having terminated by his investigations the great controversy of our day in vegetable reproduction, namely, the respective functions of the pollen and the ovulum. Our notice in the July number of the Journal, recorded the recent history of investigations in this department, as far as then known to us. We now learn that the Schleidenian view, viz: that the embryo is formed of (or in) the extremity of the pollen-tube,—has at length been definitely abandoned, both by its author, and

by Schacht, of late its most strenuous and able defender. The conversion in this case has been accomplished by one of Schleiden's own pupils, viz: by Dr. Radlkofer, who was authorized to announce this result in his memoir; and more recently Schacht, having essentially confirmed Radlkofer's views by his own observations, now admits that the pollen-tube exerts merely a fertilizing influence upon a previously existing *corpuscle* in the embryo-sac, which thereupon forms an investing coat of cellulose, and becomes the germ of the embryo. This particular view, Prof. Henfrey (in Ann. and Mag. Nat. Hist. for Sept., 1856,) claims as original with himself, and advanced in a paper read before the Linnæan Society last March; also briefly in the article "Ovule," in the Micrographic Dictionary, published a year ago, asserting "that the germinal vesicles (or corpuscles) exist in the embryo-sac before fecundation, not as complete cells, but as corpuscles of protoplasm which acquire their cellulose coat after the fertilization by the agency of the pollen-tube." But as the exactly analogous fact had been already demonstrated in the case of the spores of Algæ, &c.) "the assertion of the opinion" in the present case was very natural; though the researches referred to may be very important.

If we rightly understand the statement, Dr. Radlkofer maintains that it is not the corpuscle or vesicle contiguous to the pollen-tube, but a second one, next to the former, which becomes fertilized, and develops the embryo, and which accordingly is never in contact with the pollen-tube;—a view which may readily be harmonized with Tulasne's beautiful researches. A. G.

3. *Bentham, Notes on Loganiaceæ, (in Journal of the Proceedings of the Linnæan Society,* No. 2.)—A most judicious and thorough revision of this group of *Rubiaceæ* with a free ovary, or "a sort of artificial offset from that family," which it becomes necessary in practice to separate. We cite a portion of the introductory remarks, for the special benefit of those who maintain that families, genera, &c., are as really and strictly limited in nature as they are in our systems, i. e., when our systems are as perfect as they practically can be.

"Our natural orders, with all the improvements they have received from the most philosophical of modern botanists, are yet as dissimilar in definiteness of circumscription and apparent conformity to nature, as they are in extent. Some indeed, including the two most numerous of all, are so well characterized as to admit of no doubt. The *Cruciferæ, Leguminosæ, Umbelliferæ, Compositæ, Labiatæ, Palmæ, Orchideæ, Cyperaceæ, Gramineæ,* and several others, comprehending two-thirds of the known species of plants, are admitted by all botanists without any variation, and although, amidst the thousands of species comprised in each, there may be some one or two which may offer an exceptional character or anomalous structure, indicating some slight approach to other groups, yet we cannot have the least hesitation as to where to draw the line of demarcation. The Himalayan *Megacarpæas,* although polyandrous, are still decidedly Cruciferous, not Capparideous. The distinction between *Leguminosæ* and *Rosaceæ,* although so difficult to be expressed in words, is yet so clearly defined, that we find no single genus or species ever considered as intermediate, and, although the passage from the former into *Terebinthaceæ* through *Copaifera* and *Connarus* be really more gradual,

yet it is still between those two genera that the limits are placed by universal consent; so are they as irrevocably fixed between the closely allied genera *Teucrium* and *Vitex*, which form the connecting link between *Labiatæ* and *Verbenaceæ*. The vast orders of *Umbelliferæ* and *Compositæ* are equally isolated, notwithstanding the anomalous inflorescences of *Horsfieldia* and some others in the former, and of *Xanthium* in the latter, which at first sight disguise their characters. The few species of *Apostasieæ* are but anomalous *Orchideæ*, rather explaining their structure than connecting them with any particular order. *Cyperaceæ* and *Gramineæ* retain their typical structure through all the singular modifications hitherto observed.

"There are other orders again, even amongst the most numerous in species after the *Compositæ* and *Leguminosæ*, which are admitted on all sides to be natural, but upon whose precise limits few botanists can be made to agree, an almost continuous chain of intermediate groups connecting them with adjoining ones. Here the severance has generally been made wherever the links have appeared the weakest; but as these weak points have been variously appreciated by different minds, and no definite standard has been adopted for testing them, the greatest uncertainty has been the consequence. *Malvaceæ* are connected with *Tiliaceæ* by numerous genera, which some would unite into one intermediate order, whilst others consider them as constituting from two to six or seven independent ones, and others again propose uniting more or less of these groups with *Malvaceæ*. The *Memecyleæ* are in the eyes of some botanists one or two intermediate families between *Melastomaceæ* and *Myrtaceæ*, whilst for others they are but a tribe of the former. So it is with the connecting groups between *Myrtaceæ* and *Passifloreæ*, between the latter and *Cucurbitaceæ*, &c. Amongst some of the largest and most universally recognized Monopetalous orders the connexion is still more gradual, and the limits proposed more arbitrary. There can be no doubt that *Rubiaceæ*, *Apocyneæ*, *Gentianeæ*, and *Scrophularineæ* are large independent orders, indicated in nature, yet those genera now amalgamated under the name of *Loganiaceæ* bind them so firmly together, that some of them will be found even more closely allied to certain others of each of the above orders respectively than they are to each other. On the other side, *Scrophularineæ* themselves pass imperceptibly into *Solaneæ*, *Bignoniaceæ* or *Convolvulaceæ*, and through these into several others.

Since the metaphor of a chain or linear series has been found inadequate for the illustration of the connexion of the natural groups, that of a geographical area or map has been more generally resorted to. In following out this idea, we may compare the natural system to an extensive country more or less densely wooded. Here the *Compositæ*, *Leguminosæ*, and other well-defined orders may be represented by dense forests clearly separated from all others by open spaces all around them, although here and there a solitary tree or a small cluster may stand a little out from the general boundary-line. The *Malvaceæ* and *Tiliaceæ*, the *Melastomaceæ* and *Myrtaceæ*, the *Myrtaceæ* and *Passifloreæ*, these again and the *Cucurbitaceæ*, would not be separated by any clear open space, but by a tract still wooded, but of less density, in which here and there the trees would be so thinly scattered as almost to break the connexion. So

the above-mentioned Monopetalous orders, the *Rubiaceæ*, *Apocyneæ*, *Gentianeæ*, and *Scrophularineæ* would be typified by large and dense woods rather widely separated from each other, but the intervening space would be dotted over with solitary trees or small clusters representing our *Loganiaceæ*. Many of these may be very near to the surrounding woods, and considerable clear spaces may intervene between some of them; yet, in mapping out the country, it may be more convenient to draw the line close round the frontiers of the whole space, than to portion it out into projecting parcels annexed to the adjoining woods.

On a careful examination, it will be found that almost the whole of the *Loganiaceæ* lie very near to some part or other of the vast field of *Rubiaceæ*, although by their free ovary they are absolutely and (with very few exceptions) clearly separated. The connecting genera with *Apocyneæ*, *Gentianeæ*, and *Scrophularineæ* are on the other hand much fewer, but the union is much closer. With *Scrophularineæ* in particular, although the general affinity is more remote, the few intermediate genera and species are intermediate in every respect, in habit as in technical character. The main distinction, the presence of stipules in *Loganiaceæ*, disappears very gradually, and the difficulty of drawing the line is the greater from there being no general habit or family resemblance to unite the several members of the *Loganiaceæ*. A somewhat arbitrary decision is therefore here unavoidable, and we can only direct our best endeavors to the adoption of that demarcation which shall interfere the least with the circumscription of the allied orders."

One of the most interesting facts of detail in the memoir is the identification of a second species of our genus *Gelsemium* (the so-called *Jessamine* of our Southern States) in China (Hong Kong) and Sumatra; and another is the suppression of the genus *Ignatia*, it being proved to have been founded on the blossoms of the Rubiaceous genus *Posoqueria*, and the seed of a *Strychnos*.

A. G.

4. *The Flowers of the Pea-Nut* (*Arachis Hypogæa*, L.)—Mr. Bentham authorises us to state that the views formerly published by him attributing to *Arachis* two very distinct kinds of flowers,—namely, one achlamydeous and fertile, the other complete but sterile,—he is now satisfied are incorrect. The mistake here acknowldged was first pointed out by Hugh M. Neisler, Esq., last year, in this Journal (vol. 19, 2nd ser., p. 212, March, 1855). Mr. Neisler, who has enjoyed the best opportunities of studying the living and fruitful plant in Georgia, where it is cultivated in gardens, came to the conclusion that "the flowers of *Arachis hypogæa* are all petal-bearing and all fertile." This communication called out an "additional note" by Mr. Bentham, (in the Kew Journal of Botany, and reprinted in this Journal, vol. xx, p. 202, Sept. 1855), reiterating his former views, and announcing that he had confirmed them by new observations upon *Arachis* and its allies. Mr. Bentham now informs us that he has been made aware of his mistake, recently, through the examination of a large number of spikes of *Stylosanthes* from their earliest stage of development. He remarks that "although I always found fecundated ovaries very different in the shape of their short styles from the base of the style in the unopened or just-expanded flowers; yet after some time I succeeded in tracing, as Mr. Neisler has done in

Arachis, the change from the one to the other. The moment the style breaks off, the lower fragment curves back, and forms at the end of it what I always took for a thickened stigmatic surface; but it is a mere callosity which, when examined under the microscope, shows no stigmatic papillæ. Loth as I am to be convinced of so gross an error, I must beg of you to do *amende honorable* for me to Mr. Neisler in any way you may think proper."—We are still inclined to think, but without a fresh examination, that the more fruitful flowers of *Stylosanthes* and *Lespedeza*, although similar to the others in structure, are commonly precociously fertilized in the bud, as they are in *Impatiens* and many other plants, in which, however, the fully-developed blossoms also become fruitful under favorable conditions. A. G.

5. *Martius, Flora Brasiliensis*; fasc. 16 and 17, 1856.—This imperial Flora is now carried on with such spirit that this new and large part (of two fasciculi combined) follows hard upon the last. The present part is mostly the work of Prof. Miquel, of Amsterdam. It comprises first the *Primulaceæ*. These are insignificant both in number and interest in the Brazilian flora, consisting merely of *Pelletiera* (which Miquel suspects may be a *lusus* of Asterolinon), four species of *Anagallis* (most of them introduced, no doubt), two of *Centunculus* (one of which, like our N. American plant, is identified with the European C. minimus), and six species of *Samolus*, among them both S. Valerandi, of Europe, and S. floribundus. 2. The *Myrsineæ;* to which we are pleased to see Miquel reunites both the *Theophrasteæ* and the *Ægicereæ*, and suggests that all might as well be referred as suborders to the *Primulaceæ*. It is more convenient to retain the two groups as orders, but it should be kept in mind that they are based on convenience and general habit, and not upon any important ordinal characters. The *Myrsineæ* of Brazil here embrace 56 species, about one-fifth or one-fourth of the known species of the group. 3. The *Ebenaceæ;* consisting of 4 species of *Diospyros*, and 3 of *Macreightia*. 4. The *Symplocaceæ*, admitted as an order of a single genus; but no character is mentioned in the diagnosis which definitely distinguishes it from the Styracaceæ, and some Brazilian species are noticed with even as few as five stamens.—Von Martius himself has illustrated three remarkable *genera incertæ sedis*, namely, *Diclidanthera* and *Moutabea*, which he develops the affinities of with great acuteness, and regards as a monopetalous, regular, and generally 5-carpellary form of *Polygalaceæ;* and *Hornschuchia*, which, with all its anomalies, he refers to the *Lardizabaleæ*. The present part is illustrated by 50 plates, besides two *Tabulæ Physiognomicæ*. A. G.

6. *L. R. Tulasne: Monographia Monimiacearum.* Paris, 1855, pp. 163, tab. 10.—An admirable memoir, contributed to the *Archives de Museum d' Histoire Naturelle*, vol. 8, illustrating a small family of plants, long of obscure affinity. These had for the most part been approximated to the *Laurineæ* and *Urticaceæ:* with the latter they have nothing in common; with the former only a similarity in sensible properties, and occasionally in the structure of the anther. It is now clear that the relationship of the family is with polypetalous apocarpous orders; and that it is to be associated either with *Calycanthaceæ*, or with the group of orders of which *Magnoliaceæ* may be assumed as the leading type.

Tulasne contends for the alliance with the former, relying on the general symmetry of the flowers, the perigynous insertion, and the opposite leaves. Dr. Hooker, following Lindley, apparently with more reason, adopts the other view;—assigning higher importance to the albuminous seeds and small embryo, and relying on "the principle long ago laid down by Mr. Brown, that the most perfect species of a group ought to be kept in view in determining the affinities of the whole; and therefore, laying great stress upon the genus *Hortonia*, which is hermaphrodite and petaliferous, and which, when founded, was very naturally referred to the *Schizandreæ* by Dr. Wight. The plates of this memoir, mostly designed by the author's accomplished brother, are truly admirable. A. G.

7. *Chloris Andina: Essai d'une Flore de la Region Alpine des Cordillères de l'Amerique du Sud;* par H. A. WEDDELL, M.D., etc. Paris: livr. 1–4, 4to, tab. 1–26.—This belongs to the botanical part of the publications of the Expedition of Count Castelnau,—an expedition made from Rio de Janeiro to Lima and then from Lima to Para. Dr. Weddell, who accompanied the expedition, restricts his labors, in the first instance, to the flora of the Andes within the alpine region. Following the order sketched by his late preceptor, the lamented Adrien de Jussieu, he begins with the *Compositæ.* These four fascicles are devoted to that vast family, and one or two more will evidently be required for its completion. The manner in which a botanist handles such a family as the *Compositæ*, affords a fair test of his calibre; and thus far Dr. Weddell comes fully up to the high expectations which have been formed of him. We admire the boldness and general soundness of his views in respect to the classification of *Compositæ* and the limitation of the genera. The plates are by Riocreux, one of the best of living botanical draughtsmen.

A. G.

8. *Manual of the Botany of the Northern United States: Second Edition; including Virginia, Kentucky, and all East of the Mississippi: arranged according to the Natural System;* by ASA GRAY, Fisher Professor of Natural History in Harvard University. New York: 1856. George P. Putnam & Co.—The cultivators of "the amiable science," in the Northern, Middle and Eastern States of our great confederacy, are deeply indebted to Professor GRAY, for this second and more comprehensive edition of his excellent *Manual.* It is just such a *Vade mecum* as the herborizers and young Botanists, of the region indicated, have long needed and earnestly desired. The student is not only sure to find in it, an exact description of all the known plants belonging to the "cooler-temperate vegetation" of the Union, but he finds them arranged in accordance with the principles of the most approved Natural Method,—systematically exhibiting the essential characters, and structural affinities, of the multiform Groups and Families. An artificial *Key* to the Natural Orders is also prefixed, by which the generic name of each plant and its place in the system may be readily ascertained.

It is always a real comfort, as well as a positive encouragement to the practical herborizer, to know that he possesses a work in which he may certainly find a reliable account of every indigenous and naturalized plant within the designated geographical limits; and with such an aid at command no young person properly instructed, or animated by the spirit

becoming an American citizen, should be held excusable for continuing in ignorance of the vegetation around him.

This *Manual* will of course become the constant companion of all intelligent investigators of Plants within the limits referred to: but it ought, also,—in connection with the Botanical *Text-Book*, and elementary *Lessons*, by the same author—to be introduced into every well-ordered seminary (by all means including the common schools.) of the same region. With such class books, in place of the superficial and defective compilations heretofore too generally employed, a just conception of the science would soon supercede the prevalent smattering of uncouth terms destitute of ideas; and a proper foundation would be laid in the inquiring minds of youth for a future superstructure of true Botanical knowledge.

A reform of this character is a consummation devoutly to be wished. It is, indeed, high time that the intellect of "Young America,"—in every educational department—should be placed on the right track at the start, and be so developed, in its progress, as to eschew the vulgar errors and exploded fallacies of the past. The morning of life is too short, and too precious to be wasted in acquiring ideas that are obsolete, and which, of necessity, must be afterward unlearned, or discarded.

In the confident expectation that other editions of the *Manual* will ere long be demanded, we would respectfully suggest to the accomplished and indefatigable Author, the propriety of so extending the future ones, as to comprise all the known Plants of the United States,—and thus present a valuable and most desirable compendium of the Botany of our whole country. While it would meet an urgent present want, it would serve as an exceedingly interesting *Prodromus* of that complete *National Flora*, which must one day be prepared. Such a *Prodromus*—in appropriate type—would form a couple of volumes of very convenient size; the first of which might contain the *Exogenous* Plants of the Union, and the second, the *Endogens* and *Cryptogams*. May we not hope that such a *desideratum* will speedily be supplied? W. D.

9. *Report on the present State of our Knowledge of the Mollusca of California;* by Rev. P. Carpenter, (Proc. Brit. Assoc., August, 1856; Ath., No. 1504.)—As many of the shells of California extend to Sitka, and some even to the Shantar Islands, while the shells of the *Gulf of California* belong to the Fauna of Panama and Ecuador, this report embraces the shells of the whole of the west coast of North America. The causes of error, both in ascertaining the habitat and in identifying the species of mollusks, were pointed out. An historical account was given of all the known collectors in the district, pointing out the degree of authority attached to each, with a list of species, references, synonyms, &c. Special attention had been paid to the minuter shells of the Gulf, among which were pointed out several new and interesting forms. The large multitudes of shells from that district which had been lately sent to this country had brought to light many interesting points concerning the great variations in particular species. In the genus Cæcum, for instance, five species had been made out of different stages of growth in the same shell. All the known shells of which the exact locality was ascertained had been tabulated in columns, representing the distribution of the species, and arranged zoologically. About 800 species are known from the

Gulf, and 625 from Panama, of which 218 are already known to be common to the two—eighty-nine being common to the Gulf and South America and twenty-three to the Gallapagos, which islands have very little in common with South America, more with Panama, and some little with the Indo-Pacific province. The Proboscidifera were found much more local than the rest of the Gasteropods, and these than the Bivalves, the spawn of which latter are borne through wide ranges by the currents. The Fauna of Upper California, as shown by the collections of Mr. Nuttall and the United States Exploring Expedition, are quite distinct from those of the Gulf; scarcely a score of species, and those in very limited numbers, are found in common. Very little is accurately known of the Fauna of the Peninsula. The shells on the Gulf side are, however, mainly Panamic, on the Pacific side, Californian. Scarcely a single species is common to West America and Polynesia, while not a few appear identical with West Indian forms, especially in the Gulf. Several forms reappear on the Gambia coast. A very few reach Britain, chiefly nestling bivalves. The main object of the report was to reduce to a common estimate all that was yet known on the subject, that future students might not have to go over the same ground continually, and to point out the causes of the present very unsatisfactory state of the science, as the first step towards their removal.

10. *On the Vital Powers of the Spongiadæ;* by Mr. Bowerbank, (Proc. Brit. Assoc., August, 1856; Ath., No. 1505.)—The greater portion of these observations were made on a new species of sponge, of a deep orange color, that abounds on the rocks in the vicinity of Tenby between high and low water marks, and which he has named *Hymeniacidon caruncula.* He found that while in a state of repose oscula could rarely be seen in the open state, but immediately after being placed in fresh sea-water these organs were very shortly fully expanded, and streams of water were ejected from them with considerable force; this action continued for a longer or shorter period at the will of the animal, and its termination was sometimes abrupt and at other times very gradual. After the action had ceased for a short period it might again be readily stimulated to a renewal by a supply of fresh cold sea-water, and especially if poured on to the sponge with some degree of force. The action of the oscula were not simultaneous in all parts of the same specimen, and it frequently occurred that while one group were vigorously in action another group were in complete repose. The aspect of the oscula also varied considerably,—sometimes the membranous margins were projected in the form of short tubes, while at other times they were contracted laterally so as to form a tense horizontal membrane, with a widely-expanded central orifice. The author also found the reparative powers of this species remarkably active. If the sponge was cut into three pieces, and these were again brought in contact, in less than twelve hours they became firmly re-united,—and specimens of the same species placed in close contact were united to each other in a few hours, becoming one sponge. The author, in conclusion, briefly referred to the nutritive apparatus of the Spongiadæ. He stated that nearly the whole of the interior of the animal is one large stomachal cavity, furnished abundantly with membranes covered with a coat of sarcode, similar in every respect to the mucous lining of the intestines of

the higher animals, and performing for the sponge precisely the same functions that are exerted from *Actinophrys Sol* upwards, through every gradation of animal existence, to man and the rest of the most elaborately constructed animals. This extraordinary substance, designated in *Actinophrys Sol* as sarcode by Kölliker, and in the higher animals known by anatomists as the mucous lining of the intestines, is apparently an organ of very much more importance in the process of digestion than has been generally conceived. In the Spongiadæ there is every reason to believe that the imbibition of the molecules by this substance is precisely in the manner described by Kölliker in *Actinophrys Sol*,—and from the examination of the mucous membranes of animals of every class, the author feels persuaded that the mucous lining in such animals is truly the homologue of the sarcode in the *Actinophrys Sol* and in the Spongiadæ.

11. *Gar-pikes.*—Mr. J. E. Gavit exhibited to the American Association at Albany a vase containing young gar-pikes 4 to 6 inches long from Lake Ontario, which called forth some remarks from Prof. Agassiz. The point of special interest in these representatives of the ancient Ganoids, was the occurrence of an upper lobe to the caudal fin *containing the prolonged vertebral column.* It was placed directly above that fin, was of equal length and had a lanceolate form; it moreover had a peculiar rapid vibratile motion. The vertebral column was continued in it quite to its extremity. These young fishes therefore were essentially indentical in their tails with the Palæozoic species, and in one genus of the Old Red Sandstone, named *Glypticus*, as stated by Prof. Agassiz, the tail was similar in the form of the lobes. This supernumerary lobe disappears as the fish grows older. Prof. Agassiz observed that this was among the many facts which show that the order of succession of animals in past time is exemplified now in the development of individuals. He also remarked on the fact that these Ganoid fishes resemble reptiles in the power of moving the head on the back bone (owing to the ball and socket joint of the vertebræ), and in the *quasi* tail.

IV. ASTRONOMY.

1. *New Planets.*—The number of asteroidal planets now known is *forty-two.*

Harmonia (40) was discovered Mch. 31, 1856, by *Mr. Hermann Goldschmidt*, at Paris. In apparent brightness it equaled a star of the 9–10th magnitude.

The following elements of this planet are computed by Mr. C. F. Pape, of Altona.

Epoch, 1856, May 1,45198 M. T. Berl.

Mean anomaly, -	193°	8′	43″·3		
Long. of perihelion, - -	10	45	38 ·2	}	Mn. Eqnx.
" " asc. node, -	93	8	17 ·6	}	Jan. 0, 1856.
Inclination, - - -	4	17	3 ·2		
Angle of excentricity, -	2	45	11		
Log. semi-axis major, - -	0·355603				
Log. mean daily motion, -	3·016603				

[*Astr. Nach.*, No. 1022.

2. *Daphne* (41) was discovered May 22, 1856, by *H. Goldschmidt*, at Paris. It was then about as bright as a star of 11–12th magnitude.

3. *Isis* (42) was discovered May 23, 1856, by Mr. *Pogson*, first Assistant at the Radcliffe Observatory, Oxford, Eng. It was then rather brighter than a star of the 10th magnitude.

From the observations of May 28th and June 1st at Oxford and June 9th at Berlin, Mr. C. F. Pape has computed the following elements:

Epoch, 1856, June 9,52295, M. T. Berl.

Mean anomaly,	311° 19′ 21″·9	
Long. of perihelion,	310 35 34 ·9	Mn. Eqnx.
" " asc. node,	85 13 31 ·3	Jan. 0, 1856.
Inclination,	8 8 36 ·6	
Angle of excentricity,	7 45 47 ·3	
Log. semi-axis major,	0·359801	
Log. mean daily motion,	3·010306	

[*Astr. Nach.*, No. 1031.

V. MISCELLANEOUS INTELLIGENCE.

1. *American Association for the Advancement of Science.*—The Tenth Meeting of the American Association commenced at Albany on Wednesday the 20th of August last. Prof. James Hall of Albany was President of the year. The local committee of the city had made liberal and well-appointed arrangements for the occasion, and during the sessions devoted themselves most attentively to the interests of the Association, calling forth at the close a unanimous and hearty vote of thanks. The legislative halls of the State Capitol were thrown open for the meetings, and the whole building, and also the new and spacious Geological Hall, for generous evening entertainments. The citizens of Albany in various ways expressed a welcome to the Association, giving free invitations to places of public interest, besides opening their houses to many of its members, and inviting all to evening levees. This hospitality has followed the Association since its formation, wherever it has met, but no place has exceeded the very liberal arrangements made at Albany.

The meeting was in keeping with the munificence of the city, being by far the largest that has been held, numbering among its members some from places a thousand miles off to the south and west, as well as a deputation from Canada. And if there were not a large number from Europe also, it was through no want of effort and liberality on the part of the Albanians, or of free passages offered by the steamships and packets of the Atlantic.

The sessions continued till Thursday morning, the 28th, when the Association adjourned to meet on the 12th of August, 1857, at Montreal, in compliance with an invitation from the City Council and Natural History Society of that City. The officers appointed for the ensuing year are Prof. J. W. Bailey of West Point, *President;* Prof. A. Caswell of Providence, *Vice-President;* Prof. John LeConte of South Carolina, *General Secretary;* and Prof. J. Lovering, of Cambridge, was continued as *Permanent Secretary.*

In addition to the usual sessions of the Association there were two exercises of extraordinary character, and indeed of extraordinary interest for the country. On Wednesday, the 27th, the inauguration of the State Geological Hall took place. The geological collections, owing to their extent, and their comprising the vouchers of the Geological Reports of the State Survey and especially of the Palæontological volumes by Prof. Hall, have a more than American importance.

The great address of the occasion was delivered by Prof. Agassiz, in which he ably sustained the view, that "nature can only be the work of an intellectual Being,—of Mind,—of an Individual God." Remarks were also made by Professors Dewey and Hitchcock, on the history of geological surveys in the United States; by Sir William E. Logan, on the importance of the results of the Geological Survey of New York to Canada and the world; Professor Henry, on the liberality of the citizens of Albany; President Anderson of Rochester University, on the dignity and value of Science; Prof. Chas. E. Davies of Fishkill, on the true practical as the result of an antecedent ideal; and Rev. Dr. Cox on the connection of Religion with Science.

A merited tribute was paid to the memory of the Dr. T. Romeyn Beck, of Albany and resolutions of respect to his memory were passed by silently rising.

On the following day, Thursday, there was the inauguration of the Dudley Observatory when Hon. Edward Everett delivered to an audience of five thousand, an oration of great power, admirably adapted to the occasion.

The Dudley Observatory originated in the munificence of Mrs. Dudley of Albany, lady of the late Charles E. Dudley of that city, formerly member of Congress. During the meeting a letter from Mrs. Dudley was read announcing the additional gift of $50,000 to the Observatory fund towards which Mrs. Dudley had before given $25,000.

It was also stated that through the generous pledges of support on the part of twelve citizens of Albany, Gould's Astronomical Journal would hereafter be published at Albany. Dr. B. A. Gould has in charge the completion of the Observatory and the ordering of its instruments, part of which are already supplied; and under his auspices, if the endowment reaches the amount required for action, Albany will have, as we believe, an Observatory unsurpassed in the land.* It has already proposed to supply the city and shipping of New York with astronomical time.

From the address of Hon. Edward Everett, we cite a single eloquent passage on Galileo.

Galileo.—"On this great name, my Friends, assembled as we are to dedicate a temple to instrumental astronomy, we may well pause for a moment.

"There is much, in every way, in the city of Florence to excite the curiosity, to kindle the imagination, and to gratify the taste. Sheltered on the north by the vine-clad hills of Fiesole, whose cyclopean walls carry back the antiquary to ages before the Roman, before the Etruscan power, the flowery city (Fiorenza) covers the sunny banks of the Arno with its

* Since the adjournment of the Association we learn of the gift towards the Observatory of $10,000 by T. W. Olcott, Esq., of Albany.

stately palaces. Dark and frowning piles of mediæval structure; a majestic dome, the prototype of St. Peter's; basilicas which enshrine the ashes of some of the mightiest of the dead; the stone where Dante stood to gaze on the Campanile; the house of Michael Angelo, still occupied by a descendant of his lineage and name, his hammer, his chisel, his dividers, his manuscript poems, all as if he had left them but yesterday; airy bridges, which seem not so much to rest on the earth as to hover over the waters they span; the loveliest creations of ancient art, rescued from the grave of ages again to enchant the world; the breathing marbles of Michael Angelo, the glowing canvas of Raphael and Titian, museums filled with medals and coins of every age from Cyrus the younger, and gems and amulets and vases from the sepulchers of Egyptian Pharaohs coëval with Joseph, and Etruscan Lucumons that swayed Italy before the Romans; libraries stored with the choicest texts of ancient literature; gardens of rose and orange, and pomegranate, and myrtle,—the very air you breathe languid with music and perfume;—such is Florence. But among all its fascinations, addressed to the sense, the memory, and the heart, there was none to which I more frequently gave a meditative hour during a year's residence, than to the spot where Galileo Galilei sleeps beneath the marble floor of Santa Croce; no building on which I gazed with greater reverence, than I did upon the modest mansion at Arcetri, villa at once and prison, in which that venerable sage, by command of the Inquisition, passed the sad closing years of his life. The beloved daughter on whom he had depended to smooth his passage to the grave, laid there before him; the eyes with which he had discovered worlds before unknown, quenched in blindness:

> Ahime! quegli occhi si son fatti oscuri,
> Che vider più di tutti i tempi antichi,
> E luce fur dei secoli futuri.

That was the house, 'where,' says Milton (another of those of whom the world was not worthy), 'I found and visited the famous Galileo, grown old—a prisoner to the Inquisition, for thinking on astronomy otherwise than as the Dominican and Franciscan licensers thought.'* Great Heavens! what a tribunal, what a culprit, what a crime! Let us thank God, my Friends, that we live in the nineteenth century. Of all the wonders of ancient and modern art, statues and paintings, and jewels and manuscripts,—the admiration and the delight of ages,—there was nothing which I beheld with more affectionate awe than that poor, rough tube, a few feet in length,—the work of his own hands,—that very 'optic glass,' through which the 'Tuscan Artist' viewed the moon,

> 'At evening, from the top of Fiesole,
> Or in Val d'Arno, to descry new lands,
> Rivers, or mountains, in her spotty globe.'

That poor little spy-glass (for it is scarcely more) through which the human eye first distinctly beheld the surface of the moon—first discovered the phases of Venus, the satellites of Jupiter, and the seeming handles of Saturn—first penetrated the dusky depths of the heavens—first pierced the clouds of visual error, which, from the creation of the world, involved the system of the Universe.

* Prose Works, vol. i, p. 213.

"There are occasions in life in which a great mind lives years of rapt enjoyment in a moment. I can fancy the emotions of Galileo, when first raising the newly-constructed telescope to the heavens, he saw fulfilled the grand prophecy of Copernicus, and beheld the planet Venus crescent like the moon. It was such another moment as that when the immortal printers of Mentz and Strasburg received the first copy of the Bible into their hands, the work of their divine art; like that when Columbus, through the gray dawn of the 12th of October, 1492, (Copernicus, at the age of eighteen, was then a student at Cracow), beheld the shores of San Salvador; like that when the law of gravitation first revealed itself to the intellect of Newton; like that when Franklin saw by the stiffening fibers of the hempen cord of his kite, that he held the lightening in his grasp; like that when Leverrier received back from Berlin the tidings that the predicted planet was found.

"Yes, noble Galileo, thou art right, *E pur si muove.* "It does move." Bigots may make thee recant it; but it moves, nevertheless. Yes the earth moves, and the planets move, and the mighty waters move, and the great sweeping tides of air move, and the empires of men move, and the world of thought moves, ever onward and upward to higher facts and bolder theories. The Inquisition may seal thy lips, but they can no more stop the progress of the great truth propounded by Copernicus, and demonstrated by thee, than they can stop the revolving earth.

"Close now, venerable sage, that sightless, tearful eye; it has seen what man never before saw—it has seen enough. Hang up that poor little spy-glass—it has done its work. Not Herschell nor Rosse have, comparatively, done more. Franciscans and Dominicans deride thy discoveries now; but the time will come when, from two hundred observatories in Europe and America, the glorious artillery of science shall nightly assault the skies: but they shall gain no conquests in those glittering fields before which thine shall be forgotten. Rest in piece, great Columbus of the heavens—like him scorned, persecuted, broken-hearted!—in other ages, in distant hemispheres, when the votaries of science, with solemn acts of consecration, shall dedicate their stately edifices to the cause of knowledge and truth, thy name shall be mentioned with honor."

We give below a list of papers presented to the Association at their meeting. Abstracts are not here published, unless contributed by the authors, as we hold that an author should have the responsibility of presenting his own views in a Scientific Journal.

I. *Section of Mathematics, Physics and Chemistrg.*

The Elements of Potential Arithmetic; by Prof. Benjamin Peirce.

On the Next Appearance of the Periodical Comet of thirteen years; by Dr. Peters.

On Ammonia in the Atmosphere; by E. N. Horsford.

On a Possible Modification of the methods of ascertaining the density of the earth; by Stephen Alexander.

Investigation and Calculation of the results of a general process of causation; by John Patterson.

On the Law of Human Mortality; by C. F. M'Coy.

Analytical Discussion of the motion of a body under the action of central forces; by Benjamin Peirce.

On Acoustics as applied to public buildings; by Prof. Henry.

Notes on the Progress made in the Coast Survey, in prediction tables for the tides of the Coast of the United States; by A. D. Bache.

On the History and Theory of the instruments known as rotascopes, gyroscopes, etc.; by W. B. Rogers.

On Various Cyclones or Typhoons of the North Pacific Ocean, with a chart showing their course of progression; By W. C. Redfield.

On the Modifications of the Sesquioxyd of Chromium; by E. N. Horsford.

On the Relative Age of the different portions of the moon's surface, and the catastrophe to which a large portion seems to have been subjected; by Stephen Alexander.

On a New Method of measuring celestial arcs; by Alvan Clark.

Approximate cotidal lines of diurnal and semidiurnal tides of the Coast of the United States on the Gulf of Mexico; by A. D. Bache.

A Report on the New Methods of Observation now in use at the Cincinnati Observatory; by O. M. Mitchell, viz:

1. New Method of right ascension, as to its limit of accuracy.
2. New Method of declination, as to its limit of accuracy.
3. New Method of determining personal equation and personal error.
4. New Method of determining instrumental errors.
5. New Method of determining clock errors.
6. Observations on changes of figure of materials.

Morphological discussion of the laws of central forces; by Benjamin Peirce.

Further Investigation relative to the form, the magnitude, the mass, and the orbit of the asteroid planets; by Stephen Alexander.

On the Heat in the Sun's rays; by Elisha Foote.

On the Heat in the Sun's rays; by Eunice Foote.

Tidal Currents of Saturn's Ring; by Benjamin Peirce.

Remarks on Ozone observations; by W. B. Rogers.

On the Meridian Instruments of the Dudley Observatory; by B. A. Gould.

On some Special Arrangements of the Solar System, which seem to confirm the nebular hypothesis; by Stephen Alexander.

Notice of Observations to determine the cause of the increase of Sandy Hook, made by the Coast Survey, for the Commissioners on harbor encroachments of New York; by A. D. Bache.

On the Advantage of observing a lunar spot instead of a limb, in transits, for determining the difference of longitude; by Dr. Peters.

Supplement to the Paper published in the Providence Proceedings, on the secular variation in magnetic declination in the Atlantic and Gulf Coast of the United States, from observations in the 17th, 18th, 19th centuries, under permission of the Superintendent; by Charles A. Schott.

Discussion of the Secular variation of magnetic inclination in the Northeastern States, communicated under permission of the Superintendent and authority of the Treasury department; by Charles A. Schott.

Discussion of the terrestrial magnetic elements for the United States, from observations in the Coast Survey and others; by A. D. Bache and J. E. Hilgard.

On Temporary Stars, and the spheroidal origin of the forms of clusters and nebulæ; by Stephen Alexander.

On the formation of air bubbles by drops falling on the surface of water, etc.; by William B. Rogers.

On the Results of the United States Astronomical Expedition to Chili, for the determination of the solar parallax; by B. A. Gould, Jr.

An Account of a large barometer in the Hall of the Smithsonian Institution; by Joseph Henry.

On a Method of determining the latitude of a place, from the observed times when two known stars arrive at the same altitude; by W. Chauvenet.

On the Plan of Reduction of the Meteorological Observations reported to the Smithsonian Institution, adopted by the Secretary; by James H. Coffin.

On Tables of the Asteroids; by Dr. Brünnow.

Tables of Prussian Mortality, interpolated for annual intervals of age; accompanied with formulæ and process for construction; by E. B. Elliott.

Process for deducing accurate average duration of life, present values of life annuities, and other useful tables involving life contingencies from returns of population and deaths, *without the intervention of a general interpolation*; by E. B. Elliott.

On the Increase of Accuracy in the mean result, by augmenting the number of observations; by Dr. Peters.

On the Stability of satellites revolving in narrow orbits; by Daniel Vaughan.

Researches on the ammonia-cobalt bases; by Dr. Wolcott Gibbs and Dr. F. A. Genth.

On the Production of Rotary Currents in air and other gases, with a special illustration of a rotary current rendered luminous by flame and incandescent charcoal; by Dr. D. B. Reid.

On the Altitude and Physical Structure of the Appalachian System in the Region of the Black Mountains in North Carolina, compared with those of the White Mountains in New Hampshire; by A. Guyot.

On Some Experiments on visual direction; by John Brocklesby.

On the Phenomena of the discharge of ordinary electricity; by Joseph Henry.

Redetermination of the atomic weight of lithium; by J. W. Mallett.

Account of the Typhoon of October 28, 1854, at the Bonin Islands; with a sketch of its barometric curve, and notices of other cyclones; by John Rogers, *Com. U. S. Navy:* Communicated by W. C. Redfield.

Whirlwind and Tornado vortices; by W. C. Redfield.

Motion of a Body upon a solid of revolution, when the force is directed towards a point upon the axis; by Benjamin Peirce.

On the Physical Peculiarities of Comets; by Stephen Alexander.

A Simple Method of correcting the common nautical method of "double altitudes" of the sun, moon, or a planet, for the change of declination between the observations; by W. Chauvenet.

On the annual duration of sunlight on the earth in different latitudes; by L. W. Meech.

Researches concerning the Comets of 1783 and 1793; by Dr. Peters.

The Fundamental numeric series, and divergence of radiating parts, reduced to a simple organological idea; by Dr. T. C. Hilgard.

Note on the Rotation of a rigid body; by J. B. Cherriman.

On the Interpretation of some Cases of apparent geometric discontinuity; by J. B. Cherriman.

On the Forms of the Atoms of the simple substances of chemistry, as indicated by their atomic weights; by Stephen Alexander.

On the Meteorological Phenomena during the epidemic of 1855 at Portsmouth, Va.; by Nathan B. Webster.

On the Modification of Noremburg's Apparatus by about 4 or 5 minutes; by Sanderson Smith.

On the waters of the St. Lawrence and the Ottawa rivers; by T. Sterry Hunt.

On Efflorescence from brick masonry; by E. B. Hunt.

Report on the Observatory of Toronto; by J. B. Cherriman.

Results of a Series of Meteorological Observations made at New York Academies from 1825 to 1850 inclusive; by Franklin B. Hough.

Remarks on the Use of the aneroid barometer; by A. Guyot.

Experiments on the nozzles of blowing apparatus, made at the Smithsonian Institution; by Thomas Ewbank.

II. *Section of Natural History and Geology.*

On the Volcanic Phenomena of Kilauea and Mauna Loa; and on the dynamical theories of earthquakes, etc.; by C. F. Winslow.

On Volcanoes; by C. F. Winslow.

Exhibition of living Gar-pikes; by J. E. Gavit.

Notes on the Geology of Middle and southern Alabama; by A. Winchell.

Parallelism of Rock Formations in Nova-Scotia, with those of other parts of America; by J. W. Dawson.

Proof of the Protozoic Age of some of the altered rocks of Eastern Massachusetts, from fossils recently discovered; by W. B. Rogers.

On Carboniferous Reptiles; by Jeffries Wyman.

Permian and Triassic Systems of North-Carolinia; by Ebenezer Emmons.

General Description of the Boundary Line between the United States and Mexico; with General Notices of the topography, geology, agricultural resources, etc. of the country adjacent; by W. H. Emory.

Some Points in the Geology of the Upper Mississippi Valley; by James Hall.

On the Plan of Development in the Geological History of North America; by James D. Dana.

On the Geological Position of the Fossil Elephant of North America; by J. W. Foster.

On the Geology of the Broadtop Coal Region in Central Pennsylvania; by J. P. Lesley.

On the Orography of the western portion of the United States, with a map; by William P. Blake.

Description of a Fossil Shell found in the Sandstone of the Connecticut River Valley; by E. Hitchcock.

Sketch of the Progress of Geology in Alabama; by Michael Tuomey.

Notice of a Remarkable Instance of inclined stratification in Warren county, N. Y.; by J. D. Whitney.

On the Deposits of the fossil fishes and reptiles of Linton, Ohio; by J. S. Newberry.

On the Organization of Acanthocephala; by Dr. Weinland.

On Animal Development; by Louis Agassiz.

On some Euphotides, and other felspathic rocks; by T. Sterry Hunt.

On the Serpentines of the Green Mountains, and some of their associates; by T. Sterry Hunt.

Exhibition of Fossil Fish Remains from the Carboniferous limestones and Coal measures of Illinois; by A. H. Worthen.

Generalities of the Geology of Oregon and Northern California; by J. S. Newberry.

On the Carboniferous limestone of the Mississippi Valley; by James Hall.

Geological Observations on the Philo-volcanic Slope of the Mountains of Sonora near the Boundary, made under the direction of W. H. Emory, U. S. Commissioner; by Arthur Schott.

Exhibition of Fossil Cetacea from Maine; by A. C. Hamlin.

On Fossil Wood with structure, found by Sir W. E. Logan in the Devonian rocks of Gaspé; by J. W. Dawson.

On the Agency of the Gulf-Stream in the formation of the Peninsula and Keys of Florida; by Joseph Leconte.

Observations on the Geology of the Region between the Mississippi and the Pacific Ocean, with a Map; by Wm. P. Blake.

Review of a Portion of the recent Geological Map of the United States, published in Europe by Jules Marcou; by Wm. P. Plake.

Some Observations on the Coal fields of Illinois; by R. P. Stevens.

Mud-nests of the Tadpole, recent and fossil; by Edward Hitchcock.

Origin and Age of the red loam of Alabama, with a notice of some *loess* deposits; by A. Winchell.

So-called Human Petrifactions, by Trail Green; read by H. J. Coffin.

On the influence of light and water on the direction of the plumule and radicle in the germination of plants; by James Dascomb.

Viviparity and Oviparity; by Louis Agassiz.

On the Absence of trees from prairies; by Daniel Vaughan.

On the Classification of Turtles; by Louis Agassiz.

On the Relation of the Post-Permian Fishes of Connecticut and other Atlantic States, to the Triassic and Jurassic periods; by J. H. Redfield and W. C. Redfield.

On the Results of Collections of fossils during a period of ten years in the limestones of the Lower Helderberg; by James Hall.

The Metamorphic action of silicious thermal springs; by J. S. Newberry.

The Tertiary Flora of the Upper Missouri; by J. S. Newberry.

Statistics of some Artesian Wells of Alabama; by A. Winchell.

III. *Ethnology.*

On the Names of Animals, with reference to Ethnology; by Dr. Weinland.

On the Relations between Chinese and Indo-European Languages; by S. S. Haldeman.

On the Structure of the Algonquin Language; by Henry R. Schoolcraft.

Supposed Runic Inscriptions from the Coast of Maine; by A. C. Hamlin.

On the Value of the Physical conformation as an element of ethnological science; by Daniel Wilson.

Queries relative to some indications of human instinct, as illustrated by primitive arts; by Daniel Wilson.

Considerations upon the evidences of the early voyages of the Scandinavians to this Country, and upon the cosmical myths supposed to relate to America; by A. C. Hamlin.

2. *The Meteor of July 8th;* by W. Spillman.—Since the appearance of the large meteor on the evening of the 8th of July, I have endeavored to collect all the information I could respecting it: and as I did not see it myself, I have had to rely entirely on information obtained from others, and was thereby, at first, led into an error both as regards its angle of altitude, and the direction in which it was seen from this place. It was my first impression, (and I so expressed myself verbally, and by letters to others,) that its first appearance was, at an angle of 35° above the horizon, north-northwest of Columbus. To be more definite in its direction from this place, I took with a compass both its direction and altitude, as pointed out by Dr. Hopkins who saw it from a favorable position to observe. From the course pointed out by Dr. Hopkins, the meteor could not have been more than 20° north of northwest, nor at a greater altitude than 30° at its first appearance. Its approach toward the earth as seen from Columbus, as far as I can learn, was apparently a little north of where it first became visible; and the time that intervened between its explosion and the rumbling noise afterwards heard, was about three minutes; this however, must be considered as only an approximation, as I have seen no one who observed the time by a clock or watch:—besides, if Professor Harper be correct in his statement, that the meteor approached the earth in a northeast direction from where he observed it, four miles south of Grenada, its line of approach could not have been nearer to Columbus than sixty-two miles, which would have required about $4\frac{3}{4}$ minutes after its explosion for the sound to reach here, even when a due allowance is made for the course and force of the wind on that evening, which was from the northwest, at the rate of four miles an hour as registered by J. S. Lull, Esq., of this place, in his meteorological table.

Prof. Harper, who was four miles south of Grenada at the time of the appearance of the meteor, states in a paper published in the Memphis Appeal, that five minutes intervened between the visible explosion and the rumbling noise, consequently the explosion must have been sixty-eight miles from where he was. The meteor therefore must have been very high when it exploded, if the fragments reached the earth at or near the place designated by him, which was the south-west corner of Pontotoc, adjoining portion of Calhoun or Lafayette county, which would only be from forty to fifty miles from where he was at the time the meteor appeared. Admitting then that Prof. Harper was correct in his calculation, that the meteor approached the earth in a northeast direction from where he was, and also as seen from Columbus at an angle of 30° above the horizon, it must have been at least thirty-six miles high. At Holly Springs I learn that the meteor appeared a little east of south, and at an altitude of about 35° above the horizon, and as Holly Springs is about forty-six

miles from the line, or course of the meteor as above noticed, it would make it about thirty-two miles high.

Again admitting that the meteor when seen by Prof. Harper, was fifty miles northeast of his point of observation, and 35° above the horizon, it must have been about thirty-five miles high. Taking then the course of the meteor as indicated by Prof. Harper, as a base line, we may safely conclude that it was at least thirty miles high when it first became visible. As to its distance from the earth at the time of the explosion, I have no data to found a calculation upon. Prof. Harper however, says, "it could not have been much above the clouds."

As to where this meteorite found a resting place on *Terra Firma*, after its countless revolutions around it, for centuries past, would be a difficult task, unless some one was fortunate enough to have seen or heard it strike our globe.

We might, however, be aided very much in our search for it, if those who saw it under favorable circumstances would take the course in which they saw it, with a compass, and communicate the same to Prof. Harper, at Oxford, together with the altitude above the horizon in which they saw it, and as near as possible the time that intervened between its first appearance and the rumbling noise that followed. The writer of this article would also thankfully receive any information that any one may see proper to communicate to him, respecting the meteor under consideration.—*Columbus* (*Miss.*) *Democrat.*

Columbus, Miss., Sept. 1st, 1856.

3. *Sulphuric Acid Barometer.*—Professor Henry stated to the Association at Albany, that a barometer filled with sulphuric acid had been made for the Smithsonian Institution. The objection from its affinity for moisture is avoided by using a drying tube apparatus containing chlorid of calcium for drying the air that comes in contact with the acid. The tube is 240 inches long and three-fourths of an inch in diameter, and is inclosed in a glass case $2\frac{1}{2}$ inches in diameter. The construction was entrusted to Mr. James Green of New York.

4. *Cantonite.*—A mineral with the composition of Covelline, but a *monometric form*, has been named Cantonite by Mr. N. A. Pratt. A description of the species by Mr. Pratt will appear in our next.

5. *British Association.*—The Twenty-sixth meeting of the British Association was held this year, at Cheltenham, commencing with August 6th. The presidential address at its opening was delivered by Professor Daubeny, President of the meeting.

6. *American Geological History.*—In connection with the article, page 335, it should have been stated that the paper was read at the Meeting of the American Association at Albany in August last.

7. Obituary.—*Rev. Dr. Buckland.*—Few men have filled a wider space in public estimation for the last twenty-five years than Dr. Buckland. His name is intimately associated in the popular mind of this country with the progress of geology. He may not have possessed the natural acquirements or the philosophical acuteness of many of his contemporaries; but he possessed a heartiness of spirit, an indomitable energy of purpose, a geniality of character, which rendered him, even amongst men remarkable

for their gifts, the most remarkable. These qualities made Dr. Buckland the most prominent of a band of philosophers who gradually worked their way in geological science, redeeming it from the puerilities of a popular hypothesis, and placing it high amongst the physical sciences. In this great work Buckland was associated with Lyell, De la Beche, Sedgwick, Murchison, Phillips, and Conybeare.

Although we have now to record the death of Dr. Buckland, which took place on Thursday, the 14th inst., at Clapham, yet he had many years closed his scientific career. In the year 1850 his brain gave way under the excessive activity to which it had been exposed, and from that time to this he has never recovered sufficiently to attend to his scientific pursuits.

Dr. Buckland was born at Axminster, in Devon, in the year 1784. He received his early education at Winchester, and in 1801, obtained a scholarship in Corpus Christi College, Oxford. He took his degree of B. A. in 1803, and was elected a Fellow of his College in 1808. At this time Oxford was the most unpromising school in the world for natural science. Nevertheless there were chairs of Botany, Chemistry, and Mineralogy to indicate to the student that all human wisdom was not bound up in Classics and Mathematics. The tastes of young Buckland led him to the study of Mineralogy, and in 1813 we find him appointed to the Readership of Mineralogy, and in 1818 to the Readership of Geology. In these positions he succeeded in attracting attention to the departments of physical science which he taught. But as he excited interest he excited opposition, and every onward step that he made towards giving the science of geology a position in the University, raised an opponent to its claims. Through his long life he had to fight for his science in his Alma Mater. But he gained the victory,—and Strickland and Phillips, his successors, have obtained a universal recognition of the value and importance of their teachings.

In 1820 Dr. Buckland delivered a lecture before the University of Oxford, which was afterwards published under the title of "Vindiciæ Geologicæ; or, the Connection of Religion with Geology explained." In this work he showed that there could be no opposition between the works and the word of God, and that the influence of the study of natural science, so far from leading to atheism and irreligion, necessarily led to the recognition of God and to his worship. At this time, however, Dr. Buckland still adhered to the old hypothesis of the universality of the Deluge. He, however, became convinced of the untenability of this position, and in his Bridgewater Treatise, published in 1836, entitled "Geology and Mineralogy considered in reference to Natural Theology," we find him adopting the views of Lyell and others.

Dr. Buckland's name will ever be associated in this country with his discoveries of the remains of animals in the caves of Kirkdale, and other parts of England. Of these discoveries he first gave an account in the *Philosophical Transactions* in a paper, entitled "Account of an Assemblage of Fossil Teeth and Bones of Elephant, Rhinoceros, Hippopotamus, Bear, Tiger, and Hyæna, and Sixteen other Animals, discovered in a Cave at Kirkdale, Yorkshire, in the year 1821." These discoveries and others served as a basis for a work published in 1823, entitled "Reliquiæ Diluvianæ; or, Observations on the Organic Remains attesting the Action of an Universal Deluge." Although the occurrence of these remains are

now accounted for on a different theory, the great value of this work remains as a record of the first discovery of the remains of animals of which most have since disappeared from the world, and thus revealing the nature of the animal inhabitants of Great Britain previous to the arrival of man. In addition to the above account of the bones of animals found in caves in Great Britain, Dr. Buckland described many from the Continent, as the bones of hyænas found in the cavern of Lemel, near Montpellier, and the bones of bears found in the Grotto of Osselles, or Quingey, near Besançon.

His contributions to the *Proceedings of the Geological Society* were very numerous, and in the first volume of the "Bibliographia Geologiæ et Zoologiæ," published by the Ray Society in 1848, we find references to sixty-one distinct works and memoirs. Dr. Buckland's social habits often led him to work with others. Thus we find him early in his career working out the southwestern coal district of Gayland in company with his friend Conybeare. In conjunction with the same distinguished geologist, he published "Sectional Views of the North-East Coast of Ireland" and "Illustrations of the Landslip on the Coast of Devonshire." With the late Sir H. De la Beche, he published a paper in the *Transactions of the Geological Society* "On the Geology of the Neighborhood of Weymouth." In conjunction with the late Mr. Greenough, he published a paper on "Vitreous Tubes in Sand-hills near Dirg. in Cumberland." With Mr. Sykes, a paper on the interior of the dens of living hyænas. His papers generally display great powers of observation, with unwearied industry; and many of the general conclusions arrived at by the author have now become part and parcel of the great laws of geological science.

In 1825 Dr. Buckland accepted from his college the living of Stoke Charity, near Whitchurch, Hants; in the same year he was promoted to a Canonry in the Cathedral of Christ Church, and married Miss Mary Morland, of Abingdon. In 1818 he had been elected a Fellow of the Royal Society; and in 1829 he was chosen a member of the Council of that body, and was re-elected on each successive occasion till his illness in 1849. In 1813 he became a Fellow of the Geological Society, and was twice elected President of that body. He took an active interest in the formation of the British Association for the Advancement of Science, and was one of those who took the bold step of inviting this body to hold its second meeting in the University of Oxford. On this occasion he was President of the Association. From that time to 1848 he was present at the meetings, and read many of his papers before them.

In 1847 Dr. Buckland was appointed a Trustee of the British Museum, and took an active part in the development of that department more especially devoted to Geology and Palæontology. He also seconded, to the utmost of his power, the efforts of Sir Henry De la Beche to establish the Museum of Economic Geology, which is now, in conjunction with the Government Geological Survey, working so successfully in Jermyn Street as the School of Mines. In 1845 Dr. Buckland received, at the hands of Sir Robert Peel, the Deanery of Westminster, vacated by the present Bishop of Oxford. This brought him to reside in London, where he immediately took a lively interest in all questions involving social amelioration. He exerted himself to gain a more free admission for the public to the Monuments in Westminster Abbey. He joined the

ranks of sanitary reformers, and brought his great knowledge of geology to bear on questions of water supply, sewerage, and other health questions. Dr. Buckland seems not to have devoted himself to questions of technical theology. His views on this subject are chiefly contained in the Bridgewater Treatise and the "Vindiciæ." Among the list of published works we find one sermon, and that devoted to the subject of death: it was published at Oxford in 1839.—*Ath., Aug.* 23, 1856.

8. *Geology of the Pacific and other regions visited by the U. S. Exploring Expedition under C. Wilkes, U. S. N., in the years* 1838–1842; by James D. Dana, Geologist of the Expedition.—This Report consists of a quarto volume of text of 750 pages, illustrated by several maps and numerous wood cuts, and a folio atlas of 21 plates. It treats of the Structure, Growth, and Distribution of Coral Reefs and Islands; of the Geology of the Sandwich Islands; the Society Islands; the Feejees; the Navigators; of the Phenomena of Volcanic Action; Changes of level in the Pacific, and origin of the general features of the Globe; of the Geology of New Zealand, Chili, and Fuegia; and a part of Oregon and California.

The folio atlas contains figures of fossils of the Coal and inferior formations of New South Wales, and of the Tertiary rocks of Oregon.

Only 200 copies of this Government Report have hitherto been printed. The author proposes to have 250 copies published for the benefit of those who are interested in the subjects. The copies will be furnished to subscribers for $12.00, the text bound in cloth, the payment to be made on delivery. A copy was recently sold in New York City for $40.00.

Should the subscription list reach 500, the edition would be increased accordingly, and the price reduced to $10.00. The work, if undertaken, will be ready for delivery in the course of the coming year.

Any person desiring one or more copies, is requested to address the author.

New Haven, October 1st, 1856.

9. *A Chronological Table of Cyclonic Hurricanes which have occured in the West Indies and in the North Atlantic from* 1493 *to* 1855; *with a Bibliographical List of Authorities;* by Andrés Poey, Esqr., of Havana.—Communicated to the British Association by Dr. Shaw. Printed by Clowes and Sons, London, pp. 40.

This pamphlet does credit to the zeal and research of Mr. Poey. It comprises a list of four hundred gales and hurricanes, with summary descriptions and references together with explanatory notes: also, a bibliographical list of four hundred and fifty Authors, Books, and Periodicals, where interesting accounts of hurricanes may be found.

Of the number of hurricanes cited by Mr. Poey as having occurred in the West Indies and Atlantic Ocean, the monthly distribution of three hundred and fifty-five was as follows, viz:

Months.	No. of hurricanes.	Months.	No. of hurricanes.
January,	5	July,	42
February,	7	August,	96
March,	11	September,	80
April,	6	October,	69
May,	5	November,	17
June,	10	December,	7
	Total,		355

Mr. Poey considers his table as only a first step to facilitate enquiries on this important subject.

10. *Descriptions of some Remains of Fishes from the Carboniferous and Devonian Formations of the United States, and of some Remains of Extinct Mammalia;* by JOSEPH LEIDY, M.D.—From the Journ. Acad. Nat. Sci. Philadelphia, 12 pp. 4to, with 3 plates.—The Species of Fishes here described, are *Edestus* (Leidy) *vorax*, from the vicinity of the Arkansas 20 miles below Fort Gibson, a gigantic fish related to Carcharodon, a fragment of the jaw of which is 6 inches long; *Oracanthus vetustus*, Leidy, from Missouri; *Petalodus Alleghaniensis*, from Blair Co., Pa.; *Holoptychius Americanus*, Leidy, Tioga Co., Pennsylvania; *Stenacanthus* (Leidy) *nitidus*, same locality as last; *Apedodus priscus*, L., Columbia Co., Pa.—The Mammals, are *Camelops Kansanus*, (Leidy) from the Territory of Kansas; *Canis primævus*, from the banks of the Ohio river a short distance below Evansville, Indiana, associated with *Megalonyx Jeffersonii*, *Bison Americanus*, *Cervus Virginianus*, *Equus Americamus*, and *Tapirus Haysii*;—*Ursus amplidens*, L., from a ravine near Natchez, Mississippi, occurring with *Equus Americanus*, *Cervus Virginianus fossilis*, *Mastodon*, *Megalonyx*, *Mylodon*, *Ereptodon*; *Ursus Americanus fossilis*, from near Natchez; *Procyon priscus*, LeConte, from Galena, Illinois.

11. *The Quarterly Journal of Pure and Applied Mathematics*, edited by J. J. SYLVESTER, M.A., F.R.S., late Professor of Nat. Phil. in University College, London, and N. M. FERRIS, M.A., Fellow of Gonville and Caius College, Cambridge; assisted by G. G. STOKES, M.A., F.R.S., Lucasian Professor of Mathematics in the University of Cambridge, A. CAYLEY, M.A., F.R.S., late Fellow of Trinity College, Cambridge; and M. HERMITE, Corresponding Editor of Paris; 8vo. London: John W. Parker and Son, West Strand; 5*s.* each number.—The first number of this Mathematical Quarterly Journal, was issued in April, 1855. The character of the work may be inferred from the distinguished names constituting its board of Editors. Each number contains 96 pages octavo, and is occupied with papers both in pure mathematics and the applications of mathematics to questions in physics, and the arts.

12. *Fossils of South Carolina;* by M. TUOMEY and F. S. HOLMES. 4to. Charleston, S. C. 1856.—Nos. 7 and 8 of this beautiful work have been issued. The plates are remarkably fine. They represent the species Pecten septenarius, Mytilus incrassatus, M. inflatus, Arca hians, A. incile, A. cœlata, A. centenaria, A. rustica, A. lienosa, A. improcera, A. transversa, A. scalaris, A. equicostata, A. incongrua, A. pexata.

13. *Abhandlungen der Kaiserlich-Königlichen Geologische Reichsanstalt.* II. Band.—4to, with 78 lithographic plates. Wien.—This splendid volume issued by the Royal Geological Society at Vienna, (1855), contains a Geological Chart of the vicinity of Schemnitz, by von Pettko, three papers by Dr. Constantine von Ettingshausen on Fossil Plants, with numerous plates, the first on the Tertiary Flora of the vicinity of Vienna; 2nd, the Tertiary flora of the Tyrol; 3d, the Carboniferous Flora of Radnitz in Bohemia; also a memoir by Dr. J. K. Andrae on the Fossil Flora (Tertiary) of Siebenburg. The third paper by von Ettingshausen, contains among its 29 plates representations of some of the most magnificent coal-plants thus far discovered. There are figures of branches of several Lepidodendra in full foliage, and in one, of the *L. Sternbergii*, the linear or acicular leaves are over a foot long, and form a dense mass about a branch 1½ inches thick, the whole two feet in length.

14. *Geognostiche Darstellung der Steinkohlen-formation in Sachsen mit besonderer Berücksichtigung der Rothliegenden*, von Hanns Bruno Geinitz; Erste Abtheilung. 90 pp. fol., with 12 lithographic folio plates. Leipzig, 1856. Verlag von Wilhelm Engelmann.—We recently noticed the beautiful work of Dr. Geinitz on the Fossil Plants of the Coal formation of Saxony. In the work just issued, the author treats of the rocks and coal beds. He first describes the various known kinds of coal from lignite to anthracite and graphite and their modes of occurrence. Next he treats of the Coal formation of the Erzgebirg Basin; (1,) the Hainich-Ebersdorf Coal formation, or the Saxon culm-coal; (2,) the productive coal beds of the vicinity of Zwickau; (3,) the Permian with the included eruptive rocks, overlying the coal measures of Zwickau; (4,) on the probable extension of coal to the west and north of Zwickau, and on the explorations for stone coal in the granulite north: with further special remarks on the Erzgebirg basin at Zwickau. Prof. Geinitz then takes up in a following chapter the anthracite region of the Upper Erzgebirg. The descriptions as well as sections exhibit with great precision the order of succession and characters of the beds of rock and coal in the coal measures of the different regions, and many facts bearing on their origin and history. The Permian is shown to be essentially a part of the Palæozoic, related to the Carboniferous Period, rather than to the Triassic.

15. *Das normal Verhältniss der chemischen und morphologischen Proportionen*, von Adolf Zeising. 112 pp. 8vo. Leipzig. Rudolf Weigel.—*O Θεὸς γεωμετρεῖ.*—The idea of simple mathematical proportions in nature is exciting much attention and research. M. Zeising in this work endeavors to trace the numbers 1 : 2 : 3 : 5 : 8 : 13 : 21 : 34, etc., which are known to occur in the arrangement of the leaves of plants, through the human figure, animal and vegetable structure, physiology, musical harmony, the planetary system, the earth's features, architecture and chemistry. And he further aims to reduce it to a still simpler form.

He divides 1000 into two parts, in such a way that the *larger* is a mean between the *smaller* and the *whole*, which gives 1000 : 618.0339 : 381·9660. This series continued, by simple proportion, making the first to the second, as the second to the third, the third to the fourth and so on: —gives 1000 : 618·03... : 381·96... : 236·06... : 145·89... : 90·16... : 55·72... : 34·44... : 21·28... : 13·15... : 8·13... : 5·02... : 3·10... : 1·92 ...: 1·18... 0·45... etc., in which the sum of any two adjoining terms equals the next preceding.

In the series $\frac{1}{1}$ $\frac{1}{2}$ $\frac{2}{3}$ $\frac{3}{5}$ $\frac{5}{8}$ $\frac{8}{13}$, etc. the last term has the value 0·618, corresponding with the value of the *larger* of the terms above, and showing that the series is based fundamentally on the preceding. M. Zeising compares the normal height of man (A) with the height of the lower part of the body (B), and of the upper (C), and states the ratio, A : B : C = 1000 : 618·0 : 381·9. Again, for the ratio of the whole lower part (A), the upper part of the leg (B), and the lower (C), the ratio A : B : C = 618·0 : 381·9 : 236·0. So also for the upper part of the body (A), and its two parts the chest (B), and the head (C), the ratio A : B : C = 381·9 : 236·0 : 145·9.—In music, the ratios 1 : 2 : 3 : 5 : 8, are given by the succession of tones C : C (octave) : G : E : C (2nd octave).—1 : 2 is the octave; 2 : 3 the fifth; 3 : 5 major sixth or minor third transposed; 5 : 8 minor sixth, or major third transposed.

For the proportion of land and water on the globe, Rigaud deduced the ratio 100 : 270, and Humboldt, the ration 100 : 280; and this corresponds with $3^2 : 5^2$ which equals 9 : 25 or 100 : 277. The land of the American continents equals 10,606,400 sq. m., and that of the other hemisphere, 27,274,000 sq. m.; the ratio is 1 : 2·57 which equals $5^2 : 8^2$. These are a few examples from the work.

16. *Principles of Chemistry, embracing the most recent discoveries in the Science, and the outlines of its application to Agriculture and the Arts.* Illustrated by numerous experiments newly adapted to the simplest apparatus; by JOHN A. PORTER, M.A., M.D., Prof. Agric. and Organic Chem. in Yale College. 480 pp. 12mo. New York, 1856. A. S. Barnes & Co. —In the preparation of this text-book, Prof. Porter has aimed at a clear, simple and practical presentation of the principles of Chemistry, not overloaded with details, and with such experimental illustrations as may be repeated with simple means, small expense, and little previous knowledge. The plan is well carried out, and the work is an excellent one for classes in Chemistry.

17. *Smithsonian Contributions to Knowledge*, vol. VIII.—*U. S. Naval Astronomical Expedition*, vol. II.—These works were not received in time for a notice in this number.

B. ALVORD: The Tangencies of Circles and of Spheres, by Benjamin Alvord, Major U.S. A.—Smithsonian Contributions to Knowledge. 16 pp. 4to, with 9 plates.

STEENSTRUPP: Hectocotyldannelsen hos Octoposlægterne Argonauta og Tremoctopus, ved Joh. Japetus Sm. Steenstrup. 32 pp. 4to, with 2 plates. Kjobenhavn. 1856.

Ninth Annual Report of the Regents of the University of the State of New York on the condition of the State Cabinet of Natural History and the Historical and Antiquarian Collection annexed thereto. Albany, 1856.

PROCEEDINGS ACAD. NAT. SCI. PHIL., VIII.—p. 101 and 106, Remarks on some Reptiles occurring near Philadelphia; *Hallowell.*—p. 102, Note on the massive spathic iron of the West side of Chesapeake bay, called Baltimore ore; *C. E. Smith.* —p. 103, On four new species of Exotic Uniones; *I. Lea.*—p. 109, Descriptions of three Myriapoda; *A. Sager.*—p. 109, Description of thirteen new species of Exotic Peristomata; *I. Lea.*—p. 111, Descriptions of fossils from the Tertiary of the Upper Missouri, with remarks on the Geology; *F. B. Meek* and *F. V. Hayden, M. D.*—p. 126, Ceratites Americanus, Prof. *L. Harper.*—p. 128, Examination of Meteoric Iron from Xiquipilco, Mexico; *W. J. Taylor.*—p. 130, Description of two new species of Urodeles from Georgia; *E. Hallowell, M. D.*—p. 131, Contributions to the Ichthyology of the Western Coast of the United States from specimens in the Museum of the Smithsonian Institution; *C. Girard, M. D.*—p. 138, New Experiments on A. St. Martin, the person experimented on by Dr. Beaumont.

Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn. 1854. No. 8–12.—Contents: Mexican and Central American Acanthaceæ, with two plates; *A. S. Oersted.*—Plants of the Haunien University, No. 2; *F. Didrichsen.*—On the occurrence of Tin ore and Cryolite in Greenland; *Th. Hoff.*—On the localities of Graphite and Eupyrchroite in the State of New York; *C. Fogh.*—On the Convolvulaceæ from Guinea in the University Museum; *A. Didrichsen.*

From Th. Kunike, successor to C. A. Koch, Greisswald.

Der Pithoanische Codex Juvenals. Erster Theil. Kritisch-exegetische Abhandlung, von Dr. A. HÄCKERMANN, Gymnasiallehrer. 40 pp. 4to. Greisswald, 1856. T. Kunike.

Index Scholarum in Universitate Litteraria Gryphisvaldensi, per semestre æstivum Anni MDLCCCLVI, a Die Mensis Afrilis habendarum. T. Kunike.

De Gravidatate Extra-uterina, accedit Descriptio memorandæ cujusdam Graviditatis Tubæ Fallopainæ sinistræ: scripsit Dr. Ferd. Bernard. Guil. Sommer; 4to, cum Tabula ænea. Greisswald. T. Kunike.

Mémoire sur une Methode Nouvelle de Transformation des Coordonnées dans le Plan et dans l'Espace, avec application aux Lignes et Surfaces des deux premiers degrés; par M. Georges Dostor, Dr. ès Sci. Math., Prof. de Math. à Paris. (Extrait du Journal Archiv der Math. u. Phys.) 78 pp. 8vo. Greifswald, 1856. T. Kunike.

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